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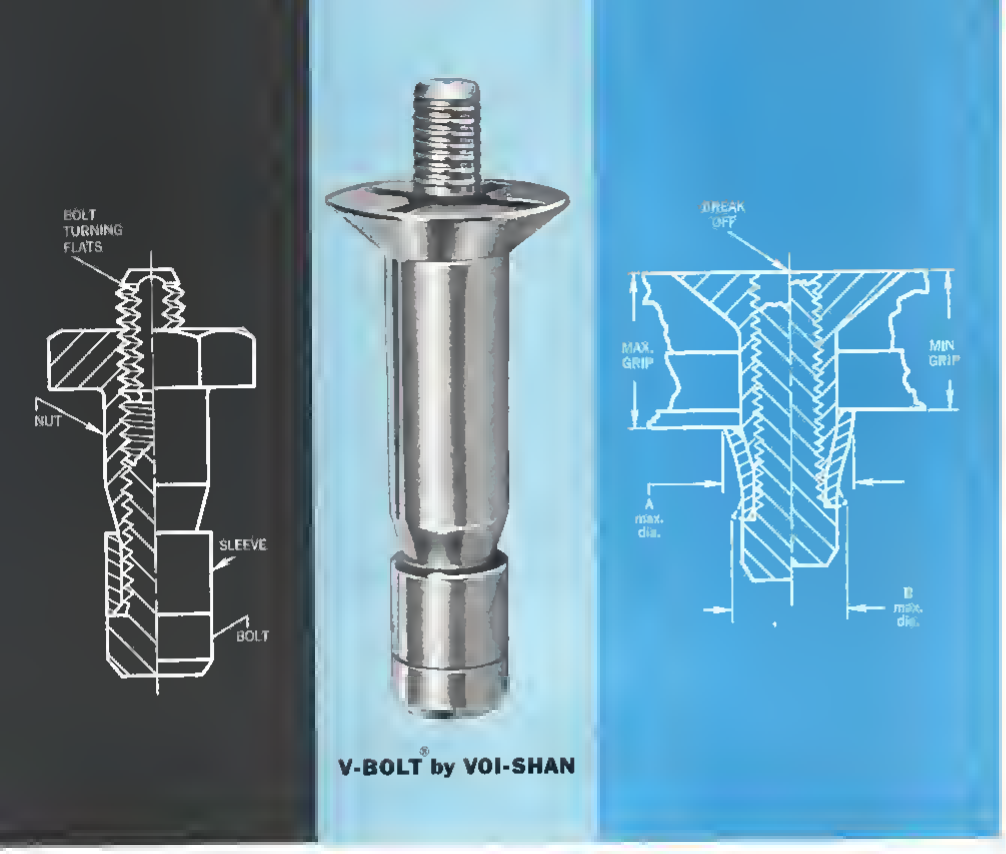
MARCH 11, 1963

Aviation Week & Space Technology

A McGRAW-HILL PUBLICATION

30th Inventory of Aerospace Power



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Why so many? Because V-Bolt, the aerospace industry's most versatile blind fastener, proven over a long period, has **wide aerospace acceptance** by prime and sub-contractors **Because** Voi-Shan's in-depth laboratory testing of all kinds has demonstrated V-Bolt **dependability;** the proof is continued customer satisfaction in the test of time **So Many,** because V-Bolt is readily available from huge Voi-Shan stocks in a variety of types and sizes to meet all blind fastener requirements V-Bolt is manufactured in many materials to meet various specific needs A-286 Alloy Steel Aluminum and 5% Chrome die steel Voi-Shan stocks a full diameter range—5/32' through 3/8' and all oversize types for repair and maintenance **Because,** in hexagonal or countersunk head configurations, V-Bolt is **simply installed** with regular crib stock tools **Proven,** by Voi-Shan's **superior engineering** quality standards—industry's high shear and tensile strength requirements are easily surpassed A variety of test data is available upon request • V-Bolt has variable grip accommodations (see drawings), and is a solution to problems in virtually all one sided structural assemblies For further details write on your letterhead to

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VSI

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Where else can you get a Navigator weighing only 48 pounds?

Don't spend too much time looking. We've checked carefully and can't find any other Doppler radar system that even approaches GPL's GPK-1000 in lightness (only 48 pounds) and compactness (only one cubic foot total for all components)

Chosen by U.S. Navy. Designated by the U.S. Navy as AN/APN-153 (V) for use in new ASW, attack and weather aircraft, this GPL system is fully operable within 45 seconds; provides automatic acquisition in less than 20 seconds, operates in any weather, 0 to 70,000 feet, retains high accuracy through virtually all aircraft attitudes. Easy to install . . . operate . . . maintain. Components can be interchanged without recalibration.

Meets Requirements of High-Performance Aircraft. Model GPK 1000 meets the air navigation needs for just about all aircraft, all speeds, all altitudes. For further details contact General Precision Aerospace, GPL Division, Dept. DPA, Pleasantville, New York

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AVIATION WEEK & Space Technology

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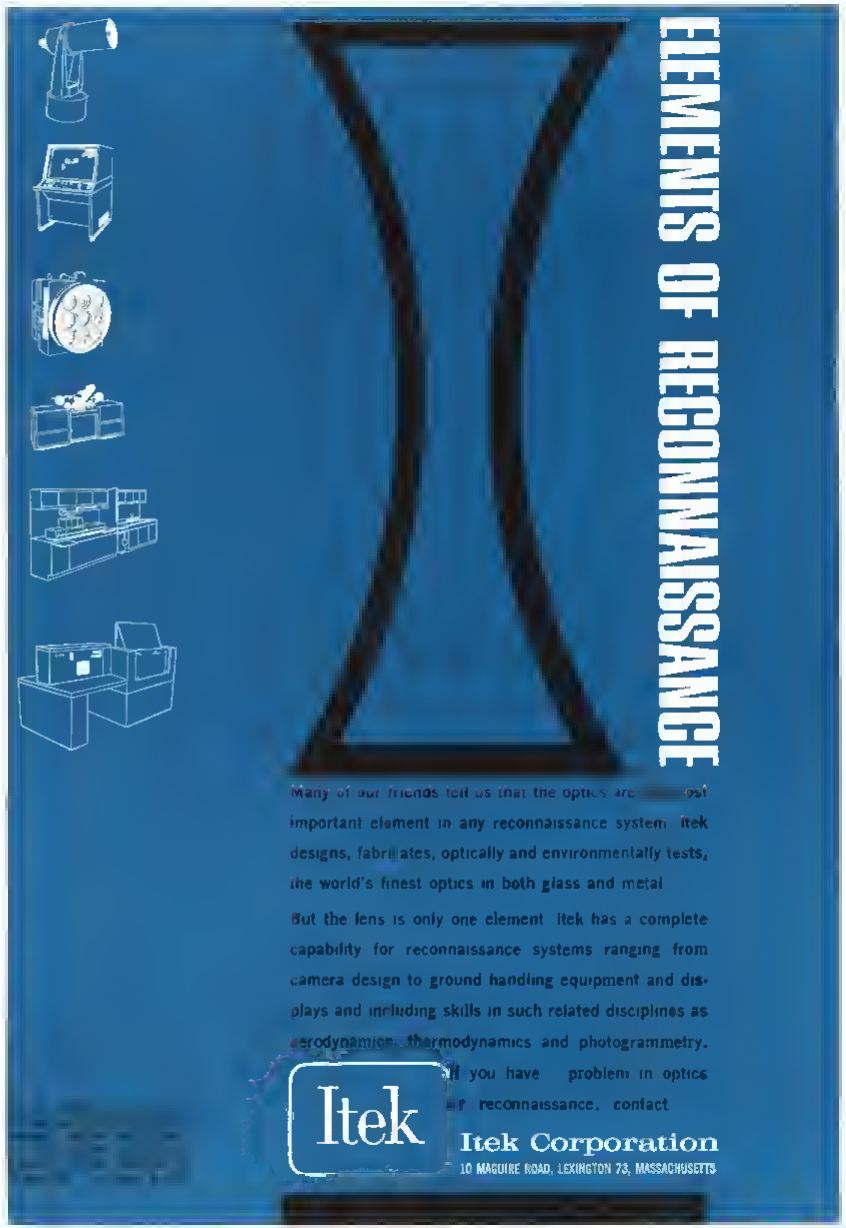

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We are heavily involved in exotic instrumentation.

A case in point is life support.

In our work to sustain human life in earth orbit, deep space and other hostile environments, we must draw upon the best capabilities to conceive, design and produce a unique array of life support systems and instrumentation.

The knowledge and experience we have accumulated in the fabrication of breathing oxygen pressure control and supply equipment over the past 30-odd years has led, in turn, to these current developments: supercritical cryogenic atmosphere supply systems, pressure control equipment, temperature and humidity control devices; toxic gas removal units and steam turbine air blowers. Systems designed and manufactured by us are in aerospace flight use as well as in toxic, radioactive, underwater and other hostile environments that utilize many combinations of our design, development and production abilities.

In addition to life support, we are involved in cryogenics, propellant measurement and control, precision special-purpose electronics. We would be pleased to help you solve your particular instrumentation problems, just write us at Dept. APR in Davenport, Iowa

Pioneer-Central Division THE Bendix CORPORATION

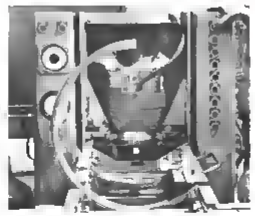
WHY A *SEMI-AUTOMATED* CYLINDER OVERHAUL LINE?

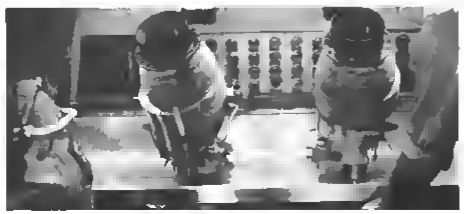
Because we still haven't found a mechanical substitute for the skill and judgement required for a high quality overhaul. There are too many variations to compensate for; almost every cylinder requires a different treatment. Airwork installed enough cylinder overhaul automation to sharply reduce the cost per cylinder . . . but retained all the stations where human judgement preserves the quality of individual cylinder overhaul methods.

For example, Airwork replaces all valve guides at overhaul. The new valve guides are reamed to exactly fit (within .0015") their mating valve stem. The valves are measured, then put in a special board that shows exactly which one goes with the cylinder being reamed. The operator mikes the valve stem, then selects the right size reamer from the more than 200 stored in the cabinet in the background.

To maintain accuracy, the normal .006" taper in the valve stem has been reduced to not more than .002" on a special honing machine before it reaches this station. The combination of a less barrel shaped valve stem and a more accurately fitted valve guide provides maximum protection against oil leaks.

Airwork uses automation to reduce the physical effort involved in handling 28-pound cylinders . . . but keeps all the skills a quality overhaul demands. This is progress —without loss of craftsmanship—one more reason an Airwork overhauled engine will provide a long, trouble-free operating life.





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Min-K® insulation does double duty on Gemini

THE INSULATION WITH A CONDUCTIVITY LOWER THAN STILL AIR CHOSEN TO PROTECT TWO ASTRONAUTS ON A TWO-WEEK ORBIT

Min-K, the insulation that performed flawlessly in the Mercury spacecraft, has been chosen by the McDonnell Aircraft Corporation for the NASA Project Gemini. This time, Min-K will be called upon to protect *two* astronauts orbiting in *one* spacecraft. And the duration of the flight may be as long as *two* weeks.

Min-K, used in the critical areas of the spacecraft, possesses the unique characteristic of markedly reducing its thermal conductivity as atmospheric pressure decreases. Min-K also has a thermal diffusivity lower than ordinary materials five times its weight.

The Gemini spacecraft will utilize another Johns-Manville insulation—J-M Thermoflex® RF Felt. As a matter of fact, Thermoflex was also used aboard all Mercury spacecraft to protect U. S. astronauts against high temperatures during blast-off and re-entry.

J-M produces a complete line of aviation insulations. For details on the entire range of products, write to J. B. Jobe, Vice President, Johns-Manville, Box 14, New York 16, New York. In Canada: Port Credit, Ontario. Cable address: Johnmanvil.

JOHNS-MANVILLE

AAE REPORTS ON ADVANCED AERIAL RECOVERY TECHNIQUES

RECOVERY—MID-AIR All American Engineering Company's aerial recovery gear for helicopters avoids costly damage to descending instrument packages and target drones. Recovery is reduced from hours (sometimes days) to minutes. When caught, the item is gently lowered to the ground, dry, undamaged, and ready to be used again. An H-43B is shown with practice capsule in tow over Holloman Air Force Base, New Mexico.

MISSILE RECOVERY An Army H-37 helicopter poised for recovery over White Sands Missile Range, this system uses All American's new Model 80D recovery winch and is capable of "air catching" packages weighing 3,000 pounds.

THE "BIG" CATCH All American developed equipment scores again as the practice capsule is brought aboard an Air Force C-130. Military services now have units whose primary missions are aerial recovery.

BALLOON STATION PICK-UP An Air Force Air Rescue Service SA-16 engages a balloon during surface-to-air recovery. First used to recover a camera packet from the "Echo II," this technique has been used to lift packages ranging from 25 pounds to nearly one ton.

Developing and proving new aerial recovery techniques began at All American Engineering Company the day airmail pick-up and delivery started over 20 years ago.

Today, the tested capabilities of All American are turned toward recovery of men, nose cones, instruments, and cargo from land, sea, and space.

All American can put 20 years of experience, trained engineers and pilots, experimental aircraft, and a unique Recovery Test Center to work for you . . . this is our business.

● For illustrated material, write to...

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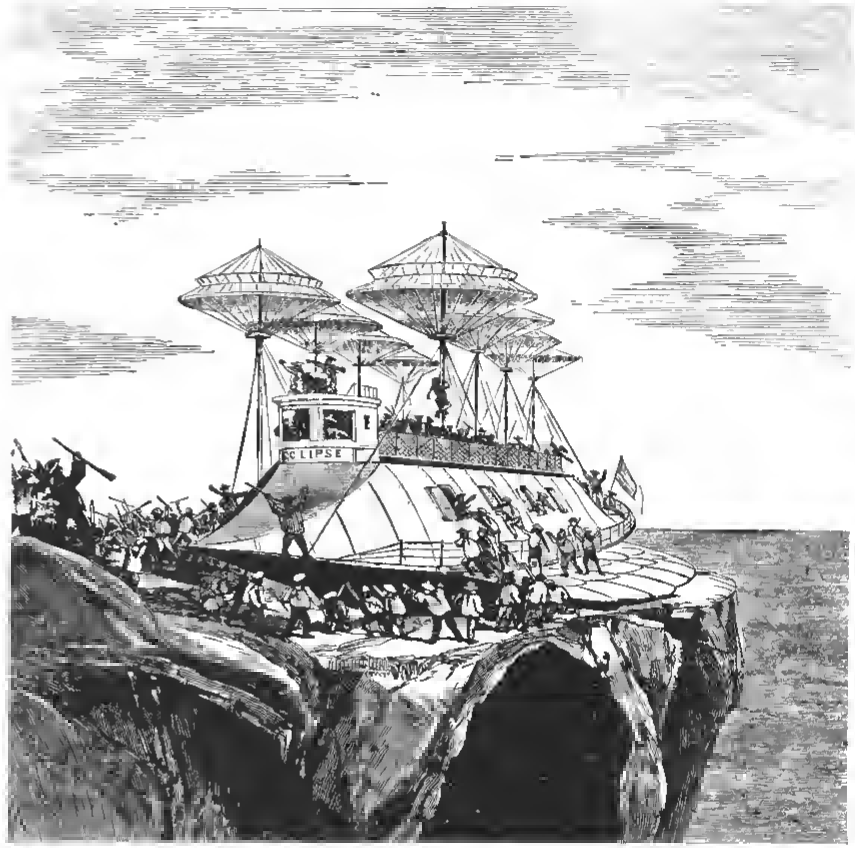


"...The disabled aircraft sat helpless as the howling pirates swarmed over it. 'If only the turbine wheels hadn't failed,' thought Captain Truehart in despair."

(Adapted from an 1892 science fiction novel)

As it was, this helicopter-type aircraft never left the pages of an 1892 science-fiction novel. Because even if the design had been right, it could never have flown. The materials to build an adequate power plant for it just didn't exist.

Today, though, an aircraft engineer can find materials to cope with almost any condition of heat, stress, or corrosion he might encounter. And many of these alloys owe their properties largely to Nickel.

For example, turbine wheels for power plants and aircraft APU's require good creep strength and oxidation resistance at extremely high temperatures. Nickel Alloy 713C has proved highly satisfactory for this application.

Alloy 713C is a cast nickel base alloy that requires no heat treatment. Small gas turbine wheels integrally cast from it can be more reliable and economical than those assembled through any other process.

If your problem is turbine wheels, you should consider Alloy 713C. Many other problems can also be solved with alloys containing Nickel.

We'll be happy to send you engineering data to help you select materials for specific aerospace applications. Write to Inco Application Engineering, outlining your requirements.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

NASA Selects Rohr To Build 210 Ft. Antenna For Goldstone

PROOF OF PERFORMANCE... LATEST CHAPTER IN THE BIG ROHR ANTENNA STORY

30 foot azimuth/elevation Antenna designed and manufactured by Rohr for Jet Propulsion Laboratory, California Institute of Technology (see above)

ACTUAL PERFORMANCE DATA VERSUS CUSTOMER'S SPECIFICATIONS

	Specified	Measured
Perpendicularity of azimuth axis to a tangent plane to the earth's surface	Within 30 seconds of arc	20 seconds of arc
Orthogonality of the elevation axis of rotation to the azimuth axis of rotation	Within 30 seconds of arc	10 seconds of arc
Symmetry of the elevation bearings to the azimuth axis of rotation	Within 0.125 inches	0.090 inches
Elevation wheel radial runout	0.010 inches peak to peak	0.007 inches peak to peak
Reflector Panels Accuracy	0.030 inches RMS Manufacturing Tolerance	
Reflector Face & Reflector Structure Accuracy	0.067 inches ($\frac{\lambda}{16}$ at 8.45 KMC)	0.008 inches RMS 0.030 inches

Rohr Offers the Complete Antenna Package from Design Through Manufacturing, Quality Control, Field Installation and Field Performance

A unique antenna concept at Rohr means complete systems responsibility from design through field test to meet customer requirements anywhere in the world . . . the antenna service now strengthened even more by proof of performance far exceeding customer specifications on Rohr designed and Rohr-built 30-foot and 85 foot antennas. The Rohr antenna concept further includes the preference to be fully responsible for servo and control systems from the outset . . . allowing for full consideration and integration through design and fabrication. Basically, our philosophy has been one of introducing a new standard of precision to meet the ever growing need for greater levels of accuracy in antenna operations. The fact that new precision standards have been achieved is proven through Rohr conducted test performance data now available. Rohr has designed, built and erected 5 antennas of widely varying sizes and configurations—for 4 customers—in 5 widely varying environmental conditions around the world. And other antennas of even more accuracy are being designed and fabricated at Rohr today.

Shown under construction is 85 foot Az/El antenna designed and built by Rohr for Radiation Corporation for Atlantic Missile Range

Rohr Antenna Research, Design and Engineering

Rohr's Antenna Systems Engineering Group was formed by recruiting from leading firms throughout the country and integrating these top antenna men with veteran Rohr aircraft engineers. This engineering group builds antenna design concepts on a broad base of knowledge acquired through the years . . . supported by intensive Rohr research in areas such as wind tests, vibration analysis, contour measuring tests, environmental studies, surface panel tests and truss evaluations.

Rohr Precision Antenna Fabrication Capabilities

Rohr's manufacturing facilities and know-how are, we believe, unmatched in the field of antenna fabrication. Our inventory of machines includes some of the world's largest presses and forming machines, numerically controlled machine tools, a battery of big bonding autoclaves, large processing tanks for chemical and heat treating, all types of automatic welding equipment, plus our tremendous, unique "antenna manufacture and assembly area" supported by huge traveling cranes and other strategic machinery. These modern antenna machines plus trained and talented antenna supervision and crews with a wealth of knowledge and experience in tooling and metal forming provide a full, seldom found antenna fabrication capability. New Rohr developed fabrication techniques such as use of large, structural weldments vs. bolted connections, and magnaflux and x-ray-controlled welding offer fabrication procedures for building in antenna accuracy levels not possible before.

Antenna Quality Control

Special quality control techniques are common procedure at Rohr. For instance, the unique, Rohr developed contour measurement system which lends a more economical and precise method of verifying specified surface tolerances. The optical theodolite used in this measuring process operates in all reflector attitudes and requires only one origin to check the relationship of the feed support and reflector surface to the antenna axis. A fully equipped and fully staffed Quality Process Control Laboratory verifies materials and certifies all applicable equipment. In addition to these and other quality control techniques at Rohr, many of the critical antenna components are test assembled in plant prior to shipment, providing factory controlled accuracy that means savings in time and money in field installation.

Antenna Field Erection

Full, follow-through on-site erection service is another important part of the complete Rohr antenna package. Today Rohr has trained, experienced, erection crews ready to provide full field installation service anywhere in the world. For instance, Rohr is erecting three antennas simultaneously in three widespread locations. Rohr maintains a high degree of coordination with other contractors—servo, electronics and others—who may be associated with a project.

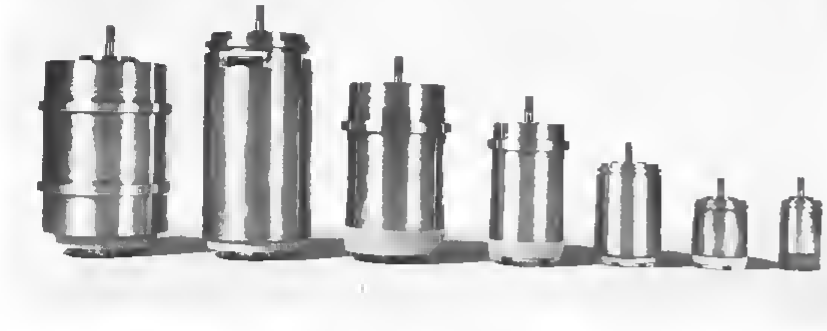
Rohr Antenna Field Test

Rohr's trained field crews work with the customer in on-site operational check-out of every antenna installation. This service extends the company's quality control responsibility through to operational readiness and assures accurate antenna performance in every attitude.

For the Complete Rohr Antenna Story Write to:

Marketing Manager, Dept. 13, Rohr Corporation, Chula Vista, Calif. Rohr Sales Offices in Washington, D.C., Huntsville, Ala.; Houston, Texas and Dayton, Ohio. Main Plant and Headquarters: Chula Vista, Calif. / Plant: Riverside, Calif. / Assembly Plants: Winder, Ga.; Auburn, Wash.

ROHR CORPORATION



Need a synchro?

Send for one of these or one of these.

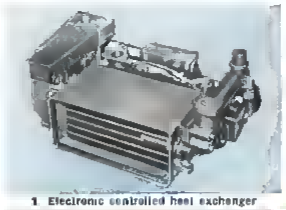
One of the advantages you'll find in coming to us for Autosyn® synchros is the personal touch. Our sales engineers work very closely with our customers.

Another advantage, of course, is the complete line that we offer. We manufacture and sell close to a thousand different types of synchros. Some of the parts have measurements as close as 50 millionths of an inch. All parts are ultrasonically cleaned before assembly.

We are currently working on units that will operate efficiently in temperatures as high as 1200°F. And we are supplying synchros that are resistant to nuclear radiation and are capable of efficient operation at 800°F.

Our test and assembly facilities have been expanded to an area covering 14,000 square feet. New equipment is permitting production of parts accurate enough for use in space and missile applications. So you see, there's nothing we can't handle in the way of synchros. Call us in South Montrose, Pa., Phone Montrose 570, TWX 199.

Montrose Division The Bendix Corporation

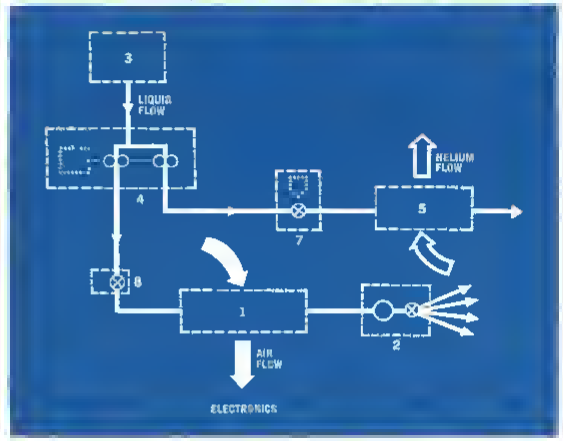


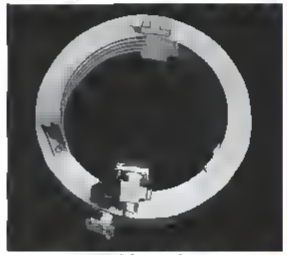
1 Electronic controlled heat exchanger

2. All altitude control system

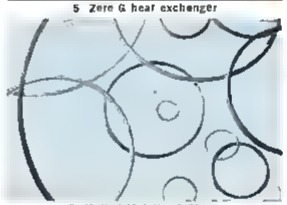
3. Fluid tanks, reservoirs—pressure vessels

4 Hydraulic power supply—pump/compressor

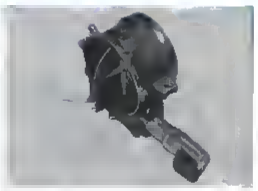




5 Zero G heat exchanger



6. United Metallic O Rings



7 Motor operated valve

8. Mass flow control valve

PARTS OR PACKAGES

UAP offers unique skills to design, develop and manufacture any component or complete, sophisticated fluid control systems for space vehicles, missiles, aircraft and ground support equipment. Virtually all components for fluid motion and control —pumps, heat exchangers, packaged electronic controls, valves, strainers, reservoirs, pressure vessels and seals are manufactured by UAP!

Complete fluid systems, designed with matched components all made by UAP, provide ultimate component compatibility, maximum system reliability, space and weight savings, simplified checkout, and single supplier responsibility. For more details, write, or phone 224-3841 today. UAP means United Aircraft Products. *Since 1929, a dynamic, independent company in Dayton, Ohio. A name to remember when it comes to fluid motion and control.*

Outstanding opportunities for qualified engineers.

UAP

Itinerant tropo scatter systems

Making a tropospheric scatter communications system is one thing. Making it air transportable and mobile is another. By distributing weight equally in vans, we've done it with the AN/MRC-98, which we are supplying for the U.S. Air Force Rome Air Materiel Area.

Any of the three vans or antenna trailers can be carried in a C-130 type aircraft. And ten men can set it up in 12 hours, to provide a completely self-contained communications terminal, including prime power.

The MRC-98 as currently delivered can relay 24 voice messages and 12 teletype messages at a time, by bouncing radio waves off the troposphere in hops of approximately 200 miles. It has the built-in capability of handling 60 voice messages and 48 teletype messages. This quadruple diversity system is reliable 12 months a year, even under the poor atmospheric conditions of the winter months.

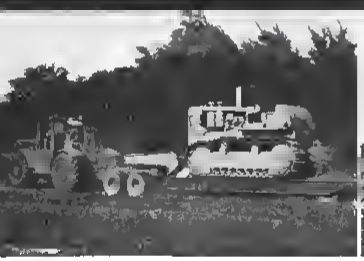
Principal components of the AN/MRC-98 10 KW system are the AN/FRC-39(V) receiver-transmitter, the AN/FCC-17 multiplexer set, in-band signaling equipment CV/566-GT, order-wire equipment, two 28-ft. parabolic reflector antennas, two 150 KW generators. It operates in the 755 to 985 mc band.

The system is compatible with the Defense Communications System long-haul circuits, and offers an economical and quick means of extending communications to new areas. For more information on this tropo scatter system, and/or militarized mobile or fixed ground stations for satellite communications, write us care of Government Marketing in Baltimore 4, Maryland.

Bendix Radio Division

THE Bendix CORPORATION

ARMY ENGINEERS WANTED MUSCLE AND HUSTLE BOTH IN ONE VEHICLE... CATERPILLAR'S CAPABILITIES CREATED THE 830M



Hustle a convoy trailer down the highway at 30 mph. Turn off the road and wade into rugged terrain. That's what Army Engineers wanted. That's what Caterpillar delivered... and is producing... the unique 830M.

Unique Capabilities... Unique Vehicles. This machine has road speed and terrain-taming power. The 830M is a 4-wheel drive articulated tractor with hydraulic steering. It took the specialized facilities and deep experience of Caterpillar to create it... a typical example of how Caterpillar capabilities can serve military needs.

First Requirement: Mobility. Here's 52,200 pounds that can snap along at 30 mph with a loaded trailer. It can turn in a 40-foot diameter. It fords 3 feet of water, rides a plane or a train (to Berne Scale specifications) and can be operated by any motor-pool driver checked out on trucks.

Second Requirement: Power. The 830M clears sites and cuts roads with a bulldozer and an 18-yard scraper. Bulldozing, it handles more than 100 bank cubic yards an hour. On a 1500 foot haul with the scraper, it moves 348 bank cubic yards an hour.

Third Requirement: Reliability. Preproduction model logged over 800 hours of bruising duty during exhaustive tests at Caterpillar's Peoria Proving Grounds. Caterpillar know-how built the 830M... Caterpillar reliability went into every working pound.

Caterpillar Added the Extras. The 830M pushes a freight car without rail damage. It pulls an amphib from the water. It can tow a tank... push a snow plow or be equipped with compactor wheels. It performs in punishing climates—from an arctic 25° below zero to a tropical 125° above (F.).

New Military Challenges. If your organization's research plans include special vehicles, components, engines or generator sets, you'll want to know more about Caterpillar's unusual research and development capabilities. Write to Defense Products Department, Caterpillar Tractor Co., Peoria, Ill.

CATERPILLAR

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Circle Number 24 on Reader Service Card

STOKES NAMED PRIME CONTRACTOR FOR NEW DOUGLAS SPACE FACILITIES

Artist's concept of Douglas Aircraft Environmental Test Center. Sketch shows test model of vehicle attached to lid end being lowered into 39' Stokes chamber. To the left are two Stokes 5 x 5s. One is shown with the solar simulator now being designed for it.

The Stokes Space System Department has been named prime contractor for the design and installation of three new space environment simulation chambers, key elements in Douglas Aircraft Corporation's privately financed Space Systems Center at Huntington Beach, California. The largest and most technically advanced space-test laboratory on the West Coast, the Center will be an integral part of Douglas' Missile and Space System Division.

The largest chamber, 39 ft. in diameter, will be capable of testing fully assembled vehicles scheduled for manned flight. It will be used in the Saturn program, and in the development of lunar and planetary probe vehicles. The Stokes systems will represent the most advanced state-of-the-art on completion, and are designed for updating to even higher simulation parameters in the future. Stokes units similar to these are now achieving vacuums in the 10^{-10} Torr range. High-speed cryopumping on all three chambers at 20°K will assure the attainment of true orbital vacuums, even under high gas loads. Stokes has assigned CryoVac, Inc. the design, fabrication and installation of cryogenic systems, and named Pittsburgh-Des Moines Steel Company to furnish and erect the large steel sphere.

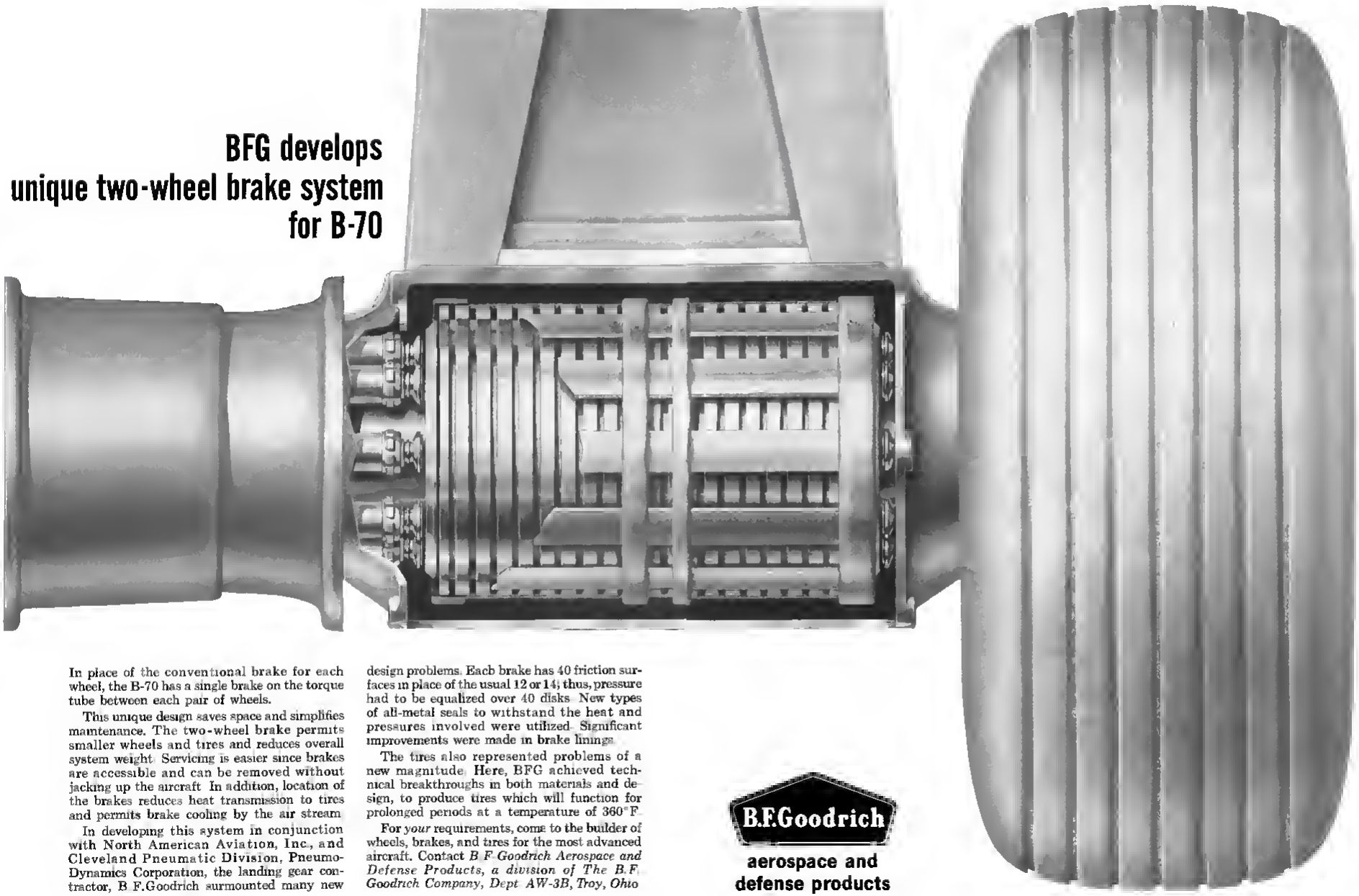
A deciding factor in the selection of the prime contractor was Stokes' experience in designing and building large, first-of-a-kind space test facilities, such as those installed at G.E.'s Space Technology Center. Another was Stokes' related background in space vacuum and cryogenics, as represented by General Electric's and Goddard's SES and DTC systems. To this experience, Stokes adds its long and successful history in the development of large-scale industrial equipment utilizing ultra-high vacuum, thorough engineering design and coordination, fabrication facilities, and field erection service... an integrated, start-to-finish capability unique in the entire area of space environment simulation. Space Systems Department, F. J. Stokes Corporation, 5500 Tabor Road, Philadelphia 20, Pa.

F. J. STOKES CORPORATION, PHILADELPHIA / LONDON / TORONTO

STOKES

Circle Number 25 on Reader Service Card

BFG develops unique two-wheel brake system for B-70



In place of the conventional brake for each wheel, the B-70 has a single brake on the torque tube between each pair of wheels.

This unique design saves space and simplifies maintenance. The two-wheel brake permits smaller wheels and tires and reduces overall system weight. Servicing is easier since brakes are accessible and can be removed without jacking up the aircraft. In addition, location of the brakes reduces heat transmission to tires and permits brake cooling by the air stream.

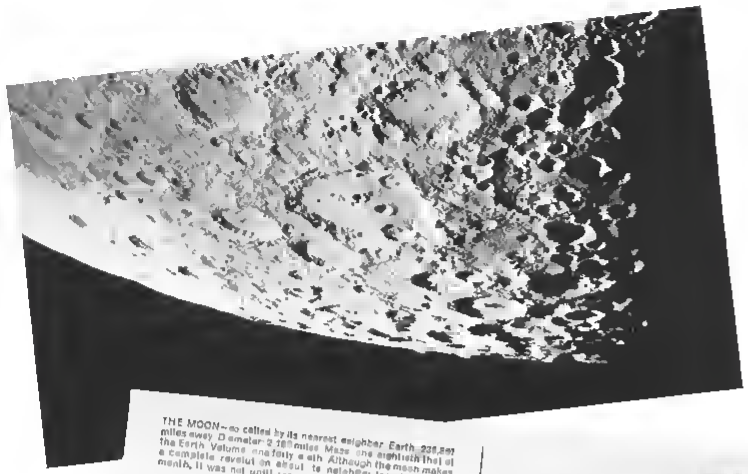
In developing this system in conjunction with North American Aviation, Inc., and Cleveland Pneumatic Division, Pneumo-Dynamics Corporation, the landing gear contractor, B.F.Goodrich surmounted many new design problems. Each brake has 40 friction surfaces in place of the usual 12 or 14; thus, pressure had to be equalized over 40 disks. New types of all-metal seals to withstand the heat and pressures involved were utilized. Significant improvements were made in brake linings.

The tires also represented problems of a new magnitude. Here, BFG achieved technical breakthroughs in both materials and design, to produce tires which will function for prolonged periods at a temperature of 360°F.

For *your* requirements, come to the builder of wheels, brakes, and tires for the most advanced aircraft. Contact *B.F.Goodrich Aerospace and Defense Products, a division of The B.F.Goodrich Company, Dept. AW-3B, Troy, Ohio*

B.F.Goodrich

aerospace and defense products

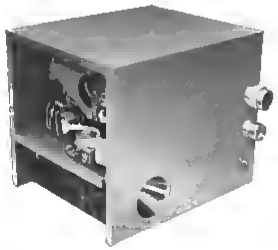


THE MOON—so called by its nearest neighbor, Earth, 238,857 miles away. Diameter: 2,160 miles. Mass: one eighteenth that of the Earth. Volume: one fifty-eighth. Although the moon makes a complete revolution about its neighbor less than every month, it was not until recently that Earth began to vary

Good trip up
Now analyzing 28 elements
Complete report being
transmitted.
GC*

MOON POSTAGE

Beckman Instruments, Inc
Fullerton, California
U.S.A.
Earth



Lunar Gas Chromatograph—
a precision analyzer in a snug, ten-inch
cube—built for NASA-JPL
in conjunction with Project Surveyor.

Designed to travel on the initial moonshot, a Beckman gas chromatograph will go to work, analyzing 28 constituents of chunks of lunar crust scooped up and fed to the little box.

In 1961, when NASA-JPL asked Beckman to take on the job, it meant creating precision equipment that could face the pull of 300 *g*, undergo the deep freeze of lunar night, and make analyses on solids rather than gases.

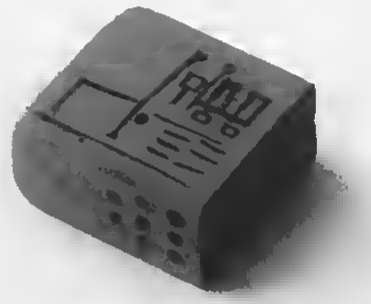
Beckman—leaders in infrared, mass spectrometry, and gas chromatography—weighed the virtues of all three techniques. The findings: *for spaceborne applications, the gas chromatograph is best.* It's unmatched for ruggedness, simplicity of design, environmental stability.

The lunar chromatograph gives the first indication of the spaceborne gas chromatograph's potential. Tomorrow, the life support system for manned flight will depend even more on the precision performance of Beckman gas chromatographs. For complete information on space-age gas analysis, write to Manager, Contract Sales.

Beckman also advances space exploration in: salalt to data processing; rocket propellant analysis; space capsule air monitoring; radiation analysis; and physiological monitoring.

Beckman INSTRUMENTS, INC.
Fullerton, California

*Gas Chromatograph



Within 2 months this eraser was able to measure time!

Inspiration plays a large part at The A.W. Haydon Company, where our only concern is with time—and timing devices.

One of our engineers—in the throes of meditation—hit upon the solution to a timing problem. Alas, no drawing board. Not even a scrap of paper!

Picking up the nearest object—a common, everyday eraser—he sketched the diagram to exact size!

Two months later, we delivered eraser-sized prototypes! We've been known to spend years finding the right solution to a sticky time problem but we never under estimate the power of the quick flash!

Inspiration, it is said, is only 2% of invention. **Vive la 2%!**

Do you have a time problem?

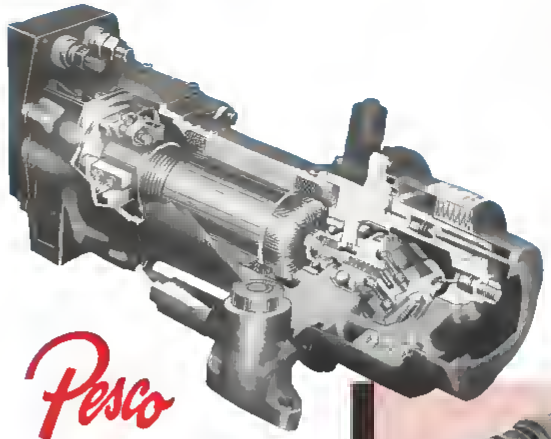
We have a timely solution!

THE A.W. HAYDON COMPANY
232 NORTH ELM STREET WATERBURY 20 CONNECTICUT

THERE IS ALWAYS AN OPPORTUNITY FOR QUALIFIED ENGINEERS AND TECHNICIANS TO GROW—IN THE FIELD OF TIME—WITH THE A. W. HAYDON COMPANY. AN EQUAL OPPORTUNITY EMPLOYER.

FROM MOUNTAIN TOP TO TABLE TOP

OPTICAL COATING LABORATORY, INC.



hydraulic power

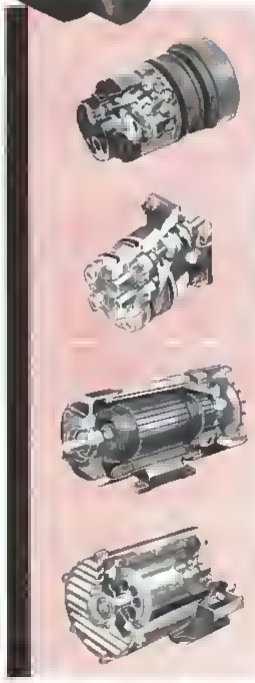
CUSTOM DESIGNED FOR AIRCRAFT, MISSILE, AND GROUND SUPPORT EQUIPMENT

Pesco

INTEGRATED HYDRAULIC POWER SUPPLIES

PRESSURES TO 5000 PSI
FLOW RATES TO 50 GPM

As a single source manufacturer of both pumps and drives, Pesco has a unique capability to custom-engineer hydraulic power supplies. Requirements of size, weight, configuration, power input and power output can be met by matching Pesco electric or hydraulic motors with Pesco fixed displacement gear pumps or variable displacement piston pumps. Pesco hydraulic power supplies are now specified for major aircraft and missile programs . . . proof of Pesco's capabilities to design, build, test, and deliver power supplies demanding high performance and reliability.



PISTON PUMPS Fixed or Variable Displacement

High speed pumps with high power output and uniform flow rates with 97% volumetric efficiency and 92% torque efficiency

pressures to 4000 psi
speeds to 24,000 rpm
flow 0.5 to 28 gpm
op. temp. range —65°F to +700°F

GEAR PUMPS Fixed Displacement

Feature patented pressure-loading design, sustained high suction and uniform flow rates with 97% volumetric efficiency and 92% torque efficiency

pressures to 5000 psi
speeds to 24,000 rpm
flow 0.2 to 50 gpm
op. temp. range —65°F to +600°F

DC ELECTRIC MOTORS

Available in seven basic frame sizes from 1.75 to 5.0 inches in diameter. Meet MIL-M-8609 specifications

voltage 6-112v
horsepower .005 to 10.0
amb. temp. —65°F to +250°F
type open-ventilated, enclosed or explosion-resistant

AC ELECTRIC MOTORS

Available in six basic frame sizes from 2.0 to 9.0 inches in diameter. Meet MIL-M-7969 specifications

voltage 115v, 208v or 416v
cycle 400
phase 1 or 3
amb. temp. —65°F to +250°F
type open-ventilated, sealed or explosion-proof

Hydraulic motors and turbine drives are also available as drives for Pesco power supplies

Request brochure and data sheets from

PESCO PRODUCTS DIVISION
BORG-WARNER CORPORATION
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BORG-WARNER

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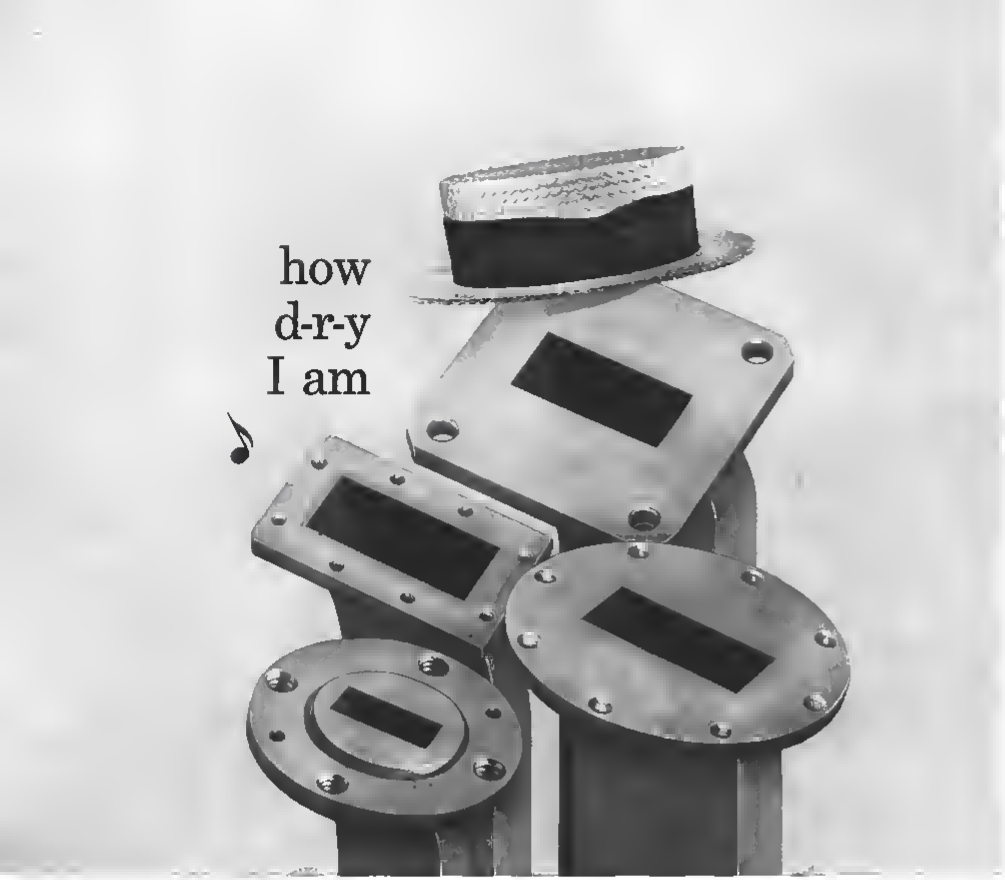
36 S. Wabash Avenue, Chicago 3, Illinois

PESCO DESIGNED HYDRAULIC POWER SYSTEMS

Pesco builds complete hydraulic power systems for aircraft and missiles which include PESCO pumps and motors, reservoirs, fluid level indicators, filters, check valves, controls, pressure switches, temperature sensing elements, radio noise filters, connectors and fittings.

1961-PC



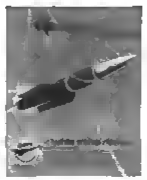
And a mighty good thing, too. Electronic designers are well aware of the extensive damage arc over can cause to high-voltage elements such as wave guides. And more often than not, they know, the culprit is moisture due to condensation.

Eastern helps combat the moisture problem with a wide range of dehydration and pressurization systems designed to protect vital electronic components. This equipment thoroughly dries the air and adds to the protection by delivering a controlled flow of pressurized dry air to prevent moist ambient air from seeping into the system.

An aggressive research program has created many outstanding developments in this field. One is Eastern's two cylinder silica gel system with built-in completely automatic change-over controls.

Another novel single cylinder system eliminates the need for switching.

Who relies on Eastern equipment? The leaders, the big name projects: Nike Ajax, Hercules, Zeus, Hawk and others.



Want to learn more? Write today for Bulletin 370.

LFE

EASTERN INDUSTRIES

A DIVISION OF LABORATORY FOR ELECTRONICS, INC.

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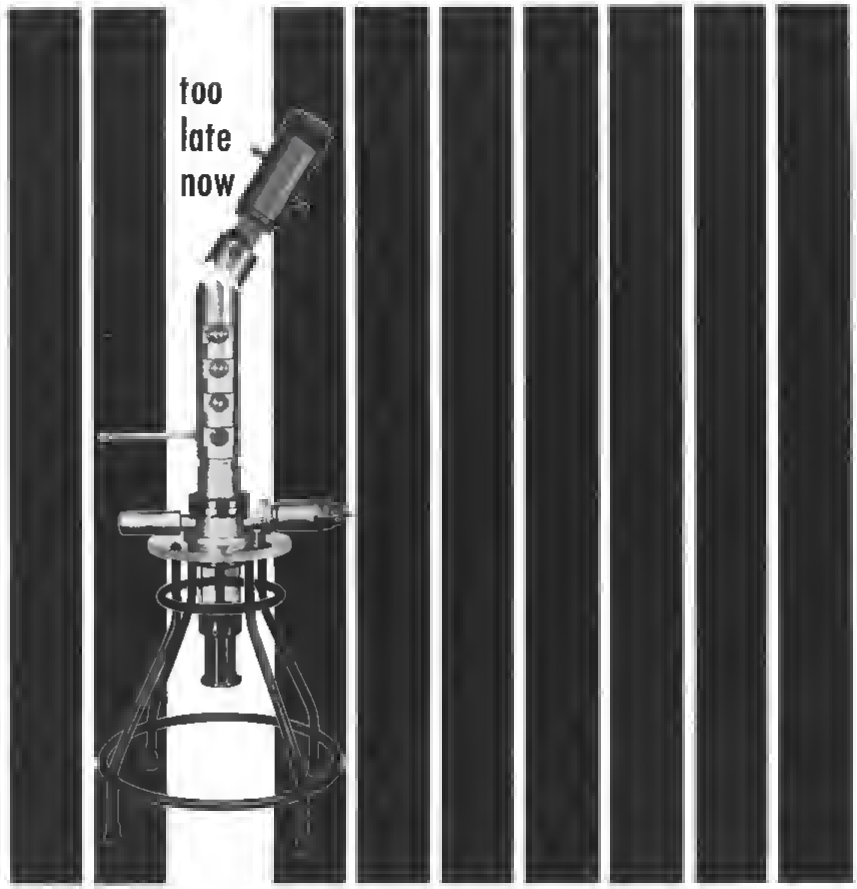
Circle Number 32 on Reader Service Card



but Warnecke microwave tube repair capability can save you thousands of dollars!

No more high cost tube replacement. No more idle equipment. Call on the one knowledgeable, capable, reliable microwave repair service available. A Warnecke Field Service Division expert will travel to your site and analyze the tube repair problem at nominal cost. Your tube is thoroughly checked, and, if repairable, is renovated in Warnecke's complete facility. It is then re-installed to function perfectly with every expectation of like new performance and durability. Warnecke's repair cost is but a small percentage of what you would pay for replacement. Your problem will be solved. Your budget greatly strengthened. Call on Warnecke now.

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FIELD SERVICE DIVISION
175 West Oakton Street, Des Plaines, Illinois
Phone 299-4438

Manufacturer of: cross field devices; storage tubes; noise source tubes, traveling wave tubes; ceramic gas-filled diodes; magnetrons, thyratrons; gas discharge tubes, Klystrons, etc.

Circle Number 33 on Reader Service Card

Only Annin valves offer the pinpoint regulation and stability required in missile ground facilities

In design and performance, Annin control valves are cryogenic workhorses in missile ground handling operations An example—the liquid hydrogen valve shown here, combining Annin's powerful electrohydraulic actuator with a vacuum jacketed valve body The Model EHA-1 actuator offers extremely fast operation, high frequency response, good positional accuracy and large thrust It is responsive to minute rapid changes in electrical signals, and delivers instantaneous action while maintaining inherent stability. Wherever adverse conditions call for advanced design and unmatched performance, you'll benefit by contacting The Annin Company, division of Worthington Corporation, 1040 S. Vail Avenue, Montebello, California. *Send for Bulletin 2000.*

Model 21760 vacuum jacketed valve with electrohydraulic actuator

Annin ★★★★ VALVES

PRODUCTS THAT WORK FOR YOUR PROFIT

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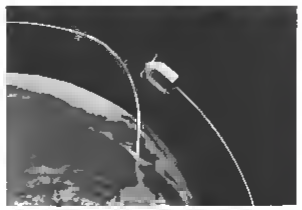
Circle Number 35 on Reader-Service Card →

FROM ASTROLABE TO APOLLO

Astrolabe (1st Century B.C.)—A Greek invention long used by Arabs and Europeans to provide astronomical sightings. The Astrolabe is a predecessor to today's sextant. (Cranbrook Institute of Science)

APOLLO PROGRAM—AC will fabricate the inertial platform with associated electronics, gyroscopes and ground support and checkout system. AC will also have responsibility for assembly and test of all navigation components.



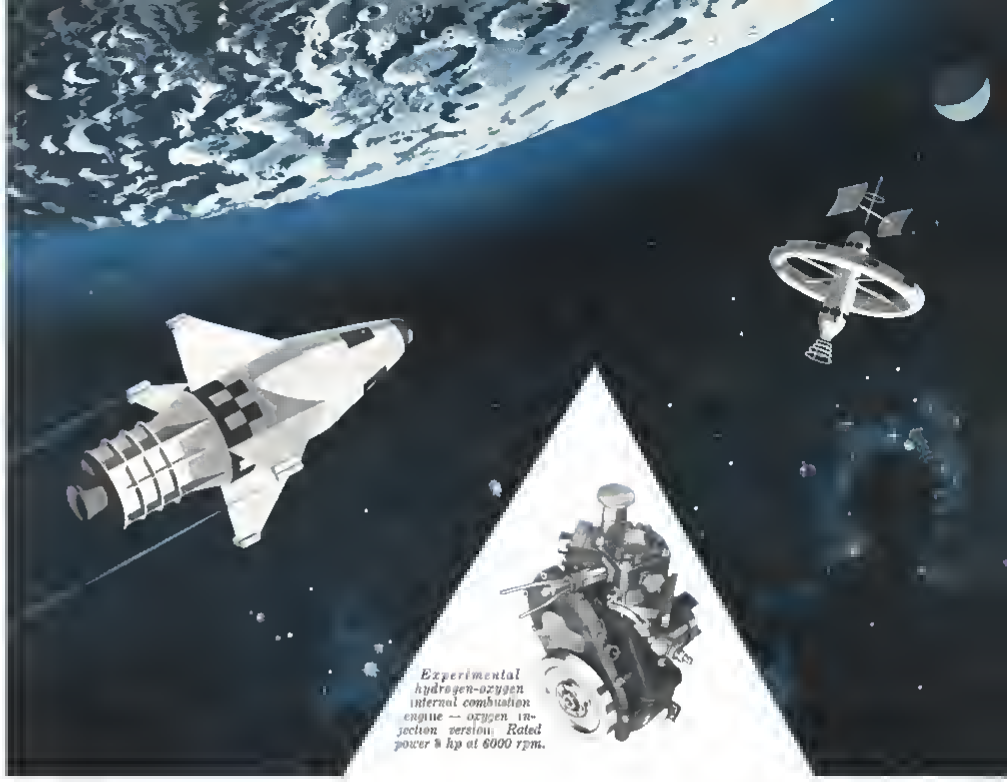
GUIDANCE BY AC MEANS—
ACCURACY, LOW COST, RAPID DEVELOPMENT, EARLY DELIVERY

The dream to navigate through space is as old as man, and today that dream is nearing reality. The capability to turn ideas into reality is found at AC. AC's ability to produce accurate systems in rapid time, at low cost with early delivery is now being applied to Guidance Systems for the USAF TITAN II and III, NASA's APOLLO Program and POLARIS inertial instruments, as well as providing Weapon System Integration and Bombing Navigational Systems for SAC aircraft.

AC welcomes the opportunity to assist you with its proven experience, facilities and manpower in system development, production and management.

MASTER NAVIGATORS THROUGH TIME AND SPACE

AC SPARK PLUG • THE ELECTRONICS DIVISION OF GENERAL MOTORS
7929 South Howell, Milwaukee 1, Wisconsin



Experimental hydrogen-oxygen internal combustion engine — oxygen injection version. Rated power 5 hp at 6000 rpm.

CAPABILITY MEANS POWER FOR SPACE AND LANDING VEHICLES

Reciprocating engines for space vehicle power systems—developed during the past four years under NASA and Air Force contracts—have successfully completed test programs at Vickers Aerospace Division. These hydrogen oxygen engines demonstrate:

READY AVAILABILITY—Designs merely require the extension of thoroughly proved mechanical principles into new areas of application. Engines are capable of operation over a wide range of speeds and power levels.

APPLICATION FLEXIBILITY—Completely integrated systems being developed by Vickers can use power from reciprocating engines in a variety of ways such as:

- In space vehicles to drive an alternator and/or hydraulic pump for equipment and personnel cooling for attitude control—even provide free drinking water as a by-product of burning hydrogen and oxygen.
- In lunar surface vehicles for propulsion power and/or auxiliary power.
- Portable power for specialized tools in lunar exploration.
- Stand-by lunar power supply.

LIGHT WEIGHT—Low specific propellant consumption (0.75 to 1.0 lbs. per hp-hr.) in conjunction with low system fixed weight is offered by internal combustion engines currently being developed—a lighter system than any other for certain space missions.

BROAD CHOICE OF FUELS—A variety of fuels—cryogenics (liquid, supercritical fluids and boil off vapor) or hypergolics—can be used.

TEST DATA AVAILABLE—For technical information and comparison of H_2 O_2 engine with other proposed systems ask for Technical Report—"Piston Engines For Space Power". Write to Vickers Incorporated, P. O. Box 302, Troy, Michigan.

[redacted]

1610

VICKERS
DIVISION OF SPERRY RAND CORPORATION

FROM THE FACILITIES
OF SPERRY FARRAGUT...

New Satellite Heart Lives Longer in Space

World's First TRUE
Brushless DC Motor

■ The new Sperry Farragut self-starting brushless direct current servomotor* offers highest efficiency/weight ratios, longest life and dependable static-free operation. It is the only TRUE brushless direct current motor made for battery operation. Others require inversion units. This solid-state commutator motor lives longer in space because there are no brushes to wear out . . . gone are the friction, arcing and wear of switching commutation necessary for conventional D.C. motors. Shown is the 7.8 oz. model being made for NASA's Goddard Space Flight Center. Characteristics include: torque .67 in.-oz. @ 3,000 rpm and efficiency of 50%. Write today for complete information.

*Patent Pending

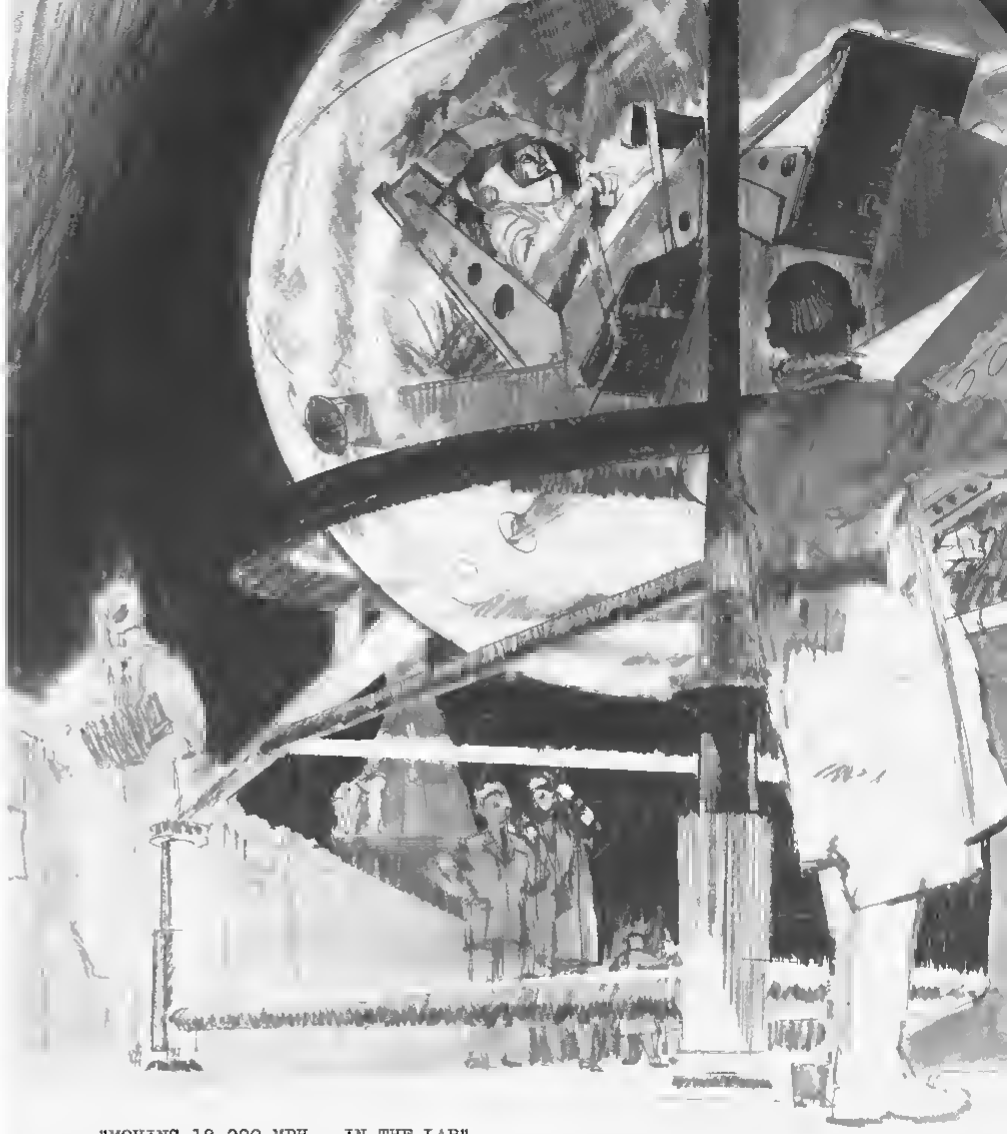
Another Space-Age First From

SPERRY FARRAGUT COMPANY

DIVISION OF SPERRY RAND CORPORATION
BRISTOL, TENNESSEE

FREE
TECHNICAL
REPORT

Write today to Dept. AW-3

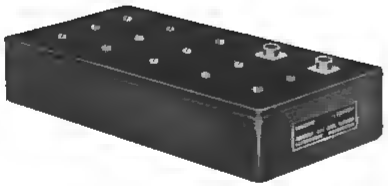


"MOVING 18,000 MPH...IN THE LAB"

Floating on a film of air, this six freedom-of-motion machine simulates the problems of rendezvous, docking and use of space tools. In proposing solutions to mobility problems such as this, Clark Equipment Company applies more than 60 years' experience in developing and manufacturing power transmission, material handling and transportation equipment. Only Clark has this unity of demonstrated capability. Invite Clark to participate in an operations analysis, product or systems development approach to your mobility problem. Write or call Manager, Clark Development Division, Clark Equipment Company, Battle Creek, Michigan.

CLARK EQUIPMENT

Grumman's orbiting astronomical observatory (OAO) will look into outer space.



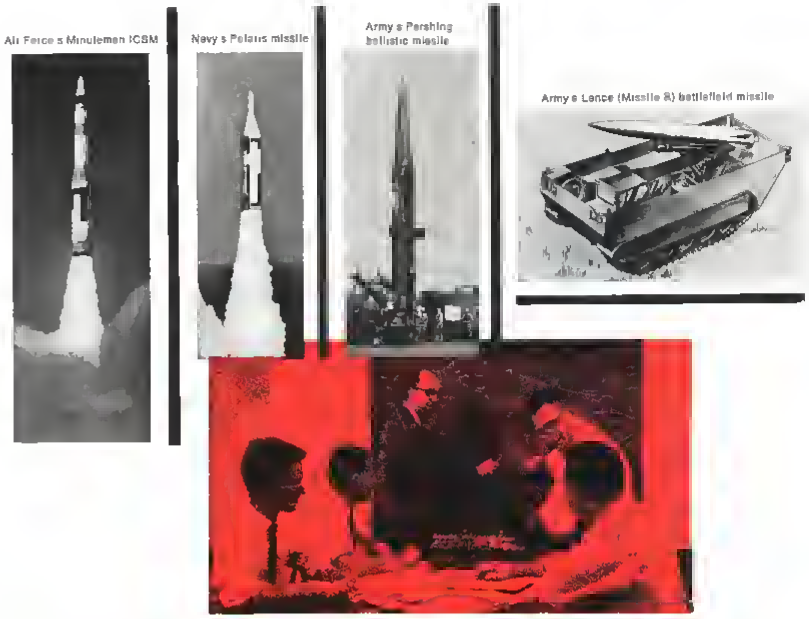
We'll look after the power.

We call the device you see a static-type battery-charge and sequence controller. It's the first unit of this type for a space application. It does several jobs: keeps battery state-of-charge up to operating limits; charges one battery at a time and maintains standby batteries inoperative; permits the operating battery to discharge during darkness to support spacecraft loads; supports the loads during daylight, if necessary; follows ground command orders; provides data on battery terminal and cell voltages, and system heat-sink temperatures—*all automatically.*

Our background in the electric power field extends over the complete range of power-generating, converting, regulating and supervisory equipment. We have one of the most complete facilities in the industry for designing and producing the aerospace power equipment you need for whatever purpose you need it.

Would you like to have more information? Write us in Eatontown, New Jersey.

Red Bank Division THE Bendix CORPORATION



FLIGHT CONTROL IS FOR PEOPLE WHO KNOW HOW

The people who know how are Systron-Donner's flight systems specialists, pioneers of the 0.1% force balance accelerometer and the use of airborne analog computing techniques. Their flight-proven achievements include instrumentation and controls for

Saturn, Surveyor, Polaris, Mercury, Atlas, Apollo, Minuteman, Pershing, Scout—and,

Most recently,

The AUTOMET* guidance system for Project Lance (Missile B)

Systron-Donner's ability to provide practical solutions for problems encompassing flight control of missiles, satellites and aircraft is based upon dual competence in both analog and digital techniques. This capability has produced an exceptionally wide range of systems interlocking time, acceleration, jerk, velocity, and displacement.

What's more, you will be surprised how quickly Systron-Donner can supply the answers and hardware for your problem. Solutions are often provided in a matter of days . . . sometimes within hours.

If these capabilities and accomplishments interest you, please write for our Flight Systems File. If you're in a hurry, call collect. Chances are we can be in your plant within 12 hours.

*Automatic Meteorological Compensation

SYSTRON-DONNER Corporation

CONCORD, CALIFORNIA

70A

SYSTRON Systems and Digital Test Instruments. DONNER Transducers and Analog Computers. GREENLEAF Gyros. ELECTROMAGNETICS Heads and Memories.

ASSIGNMENT:

Start with the free world's most powerful ICBM—Titan I.
Then . . .
Increase the payload without reducing the range.
Give it a reaction time of less than one minute.
Give it indefinite hold and salvo-firing capability.
Simplify it and reduce the cost significantly.
Engineer it to boost Gemini and other space vehicles.
Build in growth potential.
Make it operational with the Air Force in 1963.

SOLUTION: TITAN II

At Martin, systems management means the best possible product in the shortest possible time at the lowest possible cost.

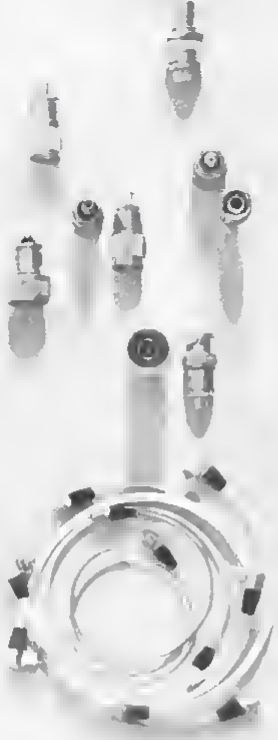
MARTIN MARTIN MARIETTA

What name is on the first 1.5 Mc recorder? **AMPEX**

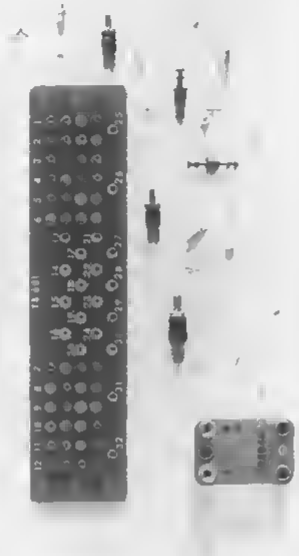
Here it is: a 1.5 Mc per track, multi track recorder! And Ampex is the first to have it. It's called the FR-1400. It will give you the broadest bandwidth yet in longitudinal recording. What's more, it utilizes solid state electronics throughout—all in one rack. It has four speeds, each electrically switchable with no adjustments needed. And it comes with tape search and shuttle to provide quick data location and permit any portion of the tape to run repeatedly without operator attention. What about performance? Outstanding! It offers better rise time and minimum ringing on square waves, low intermodulation distortion, and improved flutter. Ampex also brings you a new 1.5 Mc tape. In both you'll find the same engineering precision, the same superior quality, that has made Ampex first in the field of magnetic recording. Write the only company providing recorders and tape for every application. Ampex Corp., 934 Charter St., Redwood City, Calif. Worldwide sales and service.

AMPEX

CONNECTIONS IN DEPTH

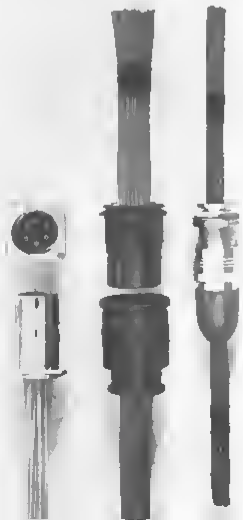


LERCO ELECTRONIC HARDWARE completes your assembly. This extensive line is available off the shelf or in custom designs including terminals, terminal boards, custom and Mil Spec knobs, eyelets and handles. Get Lerco Catalog.



Contacts, connectors, cable. Lerco electronic hardware, complete harnesses and assemblies, hermetic sealing—Microdot supplies them all miniaturized. In depth, mostly off the shelf. Because Microdot is very big on "little." Like:

MICROMINIATURE MULTIPIN CONNECTORS by Microdot are only ¼ the size of current "miniatures" and yours in 3 shell sizes—for up to 61 power or 19 coax contacts in a 1¼" shell. Parts are interchangeable inserts available in a variety of straight power, straight coaxial and combination power/coax contacts. Hermaphroditic contact arrangements can be set up with power contacts that interchange without changing inserts. Order completely custom assembled with Microdot cable or off-the-shelf in unassembled kit form. Check Bulletin MP 0.



MICROMINIATURE COAXIAL CONNECTORS by Microdot come in over 1,000,000 combinations—including the world's smallest 50 ohm job. With straight or angle screw or slide on contacts, receptacles including printed circuit and bulkhead feed thru types. With nothing but highest quality materials throughout, gold plated coin silver contacts, silver plated brass housings. Neoprene or silicone bend relief caps and "Teflon" pin protectors. Get Bulletin CX-2A.

MICROMINIATURE COAXIAL CABLES by Microdot give you all these designed in characteristics: low noise, low capacitance and high operating temperatures. They meet MIL-C-17C, yield the same matched impedance required for larger systems and come in coax, twinax and triax constructions. Silver plated copper weld or cadmium bronze conductors, "Teflon" or polyethylene dielectrics, "Teflon," "Kel-F," nylon or vinyl jackets. Order off the shelf in 50, 75, and 90 ohms impedance ratings or let us custom-manufacture in 30 to 160 ohms ratings. Write for Bulletin CBL 2A.

From crimp contacts to complete harnesses—assembled to your drawings and hermetically sealed into your equipment—Microdot supplies them all in miniature. Contact your nearby Microdot sales office, rep, or distributor. Or write us direct and tell us what you want.

MICRODOT INC.
220 Pasadena Ave., South Pasadena, Calif.
Overseas: Microdot AG, Zug, Switzerland

Circle Number 44 on Reader Service Card

New SANBORN 30-channel EVENT RECORDER

only 8¾" high, with solid-state plug-in writing control: $2050 complete

- Compact portable case or rack mounts in 8¾" of panel space
- Meets MIL I-26600/2 Class 1B RFI Spec.
- Choice of 6 solid-state plug-in Writing Controls
- Simple front-loading of 4.07" wide, 300-foot charts, hurdle paper take up
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- Confidence under worst combination of low line voltage and short duration signals, probability of marking exceeds 99%
- Response to events as short as 1.3 ms
- Constant trace intensity at all speeds
- Self cleaning, reversible stylus, replaceable individually or in groups of 30, stylus pressure automatically maintained
- 4 pushbutton-selected chart speeds, 1 to 100 mm/sec.; remote controlled chart speeds available on special order
- Signal return isolated from chassis (1 megohm min.)

Circle Number 45 on Reader Service Card

This economical new 30 channel operations monitor provides immediate permanent recording of on-off events on dry, electrosensitive charts — using pulsed writing for maximum clarity, stylus life and economy of power. Six different *interchangeable*, plug-in 10-channel *solid state* Writing Control cards are available to match your signal voltage and recording requirements. Included are types which operate with logic levels between +6 and +40 volts or −6 and −40 volts. Also, "precision types" for monitoring low level signals are available with adjustable threshold or balanced input (with respect to signal return). Model 361 system, for rack mounting or portable case, is 8¾" x 19" wide x 14½" deep, weighs approx. 50 lbs. Complete 30 channel system with either +6 v to +40 v or −6 v to −40 v Writing Control, is $2050 F.O.B. Waltham, Mass. Prices with other Writing Controls on request.

FOR UP TO 120 CHANNELS of on-off recording, Model 360 uses 16" wide, 450-foot charts, has 9 standard and 9 optional additional speeds, takes only 14" of panel space complete with integral tooling system. Solid-state plug-in Writing Control cards described above are optional. Model 360 120-channel Recorder alone $3900, prices with various Writing Controls on request.

Call your nearby Sanborn Sales Engineering Representative for complete specifications and application assistance. Offices throughout the U.S., Canada and foreign countries.

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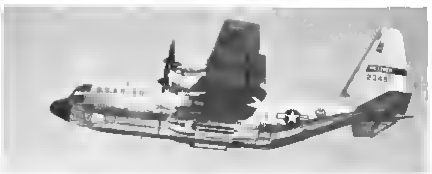
Now Hercules does something about the weather

There seems to be no end to the versatility of the C-130 Hercules airlifter. Now the giant propjet transport is a weatherbird, too.

High-altitude weather reporting is rapidly assuming a new strategic significance. Last-minute reports of the weather along the route of an airborne task force or of the cloud cover above the target of an amphibious assault can add immeasurably to the nation's ability to contain brushfire wars on a world-wide basis. To meet this need, the Air Weather Service of Military Air Transport Service is now operating five WC-130s – the new weatherbird version.

All in all, there are 500 C-130 Hercules in sixteen different versions operating throughout the free world. Most of them are in service with the United States Air Force. Others fly for the U. S. Navy, Marine Corps, and Coast Guard. Still more are in service with the air forces of Australia, Canada, and Indonesia. In addition to military airlift missions, the Hercules is a bird of peace that brings food and medicine to hungry and homeless people all over the world when disaster strikes. Ski-equipped C-130s support the scientists in Operation Deep Freeze at the South Pole. The list goes on and on and so does the C-130 production line at Lockheed-Georgia. Production will continue simultaneously with the new turbo-fan C-141 StarLifter for years to come at the Giant Marietta airlift manufacturing center.



C-130 Hercules

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Product of over 10 years' experience in storage tube design and development, today's Hughes Tonotron tubes are a result of the complete integration of capabilities from research through manufacturing —our guarantee of your satisfaction.

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Bendix Products Aerospace Division

Circle Number 51 on Reader-Service Card

THE Bendix CORPORATION

Beech works wonders with titanium to save weight... increase space payloads

Largest titanium structure ever built, and Beech built it.

The large tank in this picture is made entirely of titanium. Built by metal-working experts at Beech to hold 7,000 gallons of pressurized liquid hydrogen, the tank is eight feet in diameter and 24 feet long. This remarkable tank weighs only 460 pounds.

This means more payload.

Fabricating titanium is an old story at Beech. And if it's something that's never been done before, that's not unusual. In this case the upper and lower hemispherical tank heads were chemically milled in a complex pattern to extremely close tolerances. Production welding of .012" titanium is S.O.P. at Beech. Much of the equipment used by the Aerospace Division is one-of-a-kind and must be designed and built under the most rigid controls. Other jobs make use of Beech's extensive metal bonding capabilities.

Sophisticated fabrication is one of the many elements that make up the comprehensive Beech capability. It's one reason Beech is well prepared to undertake complete systems management responsibilities for a wide range of space-age projects.

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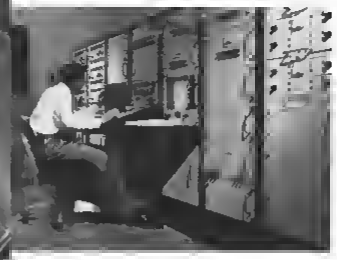
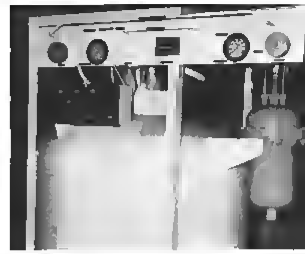


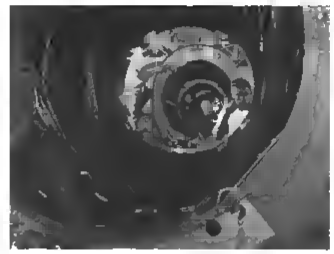
R&D...

Propulsion...



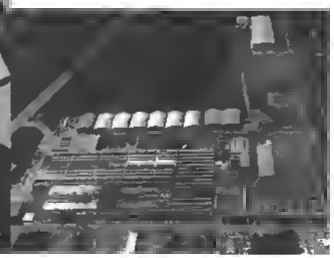
Auxiliary Power...

GSE...



Manufacturing...

Space Simulation...



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Beech Aerospace Division

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encountering secret rules

♣	➡	2	3	4
♦	➡	5	6	7
♥	➡	8	9	10
♠	➡	J	Q	K	A

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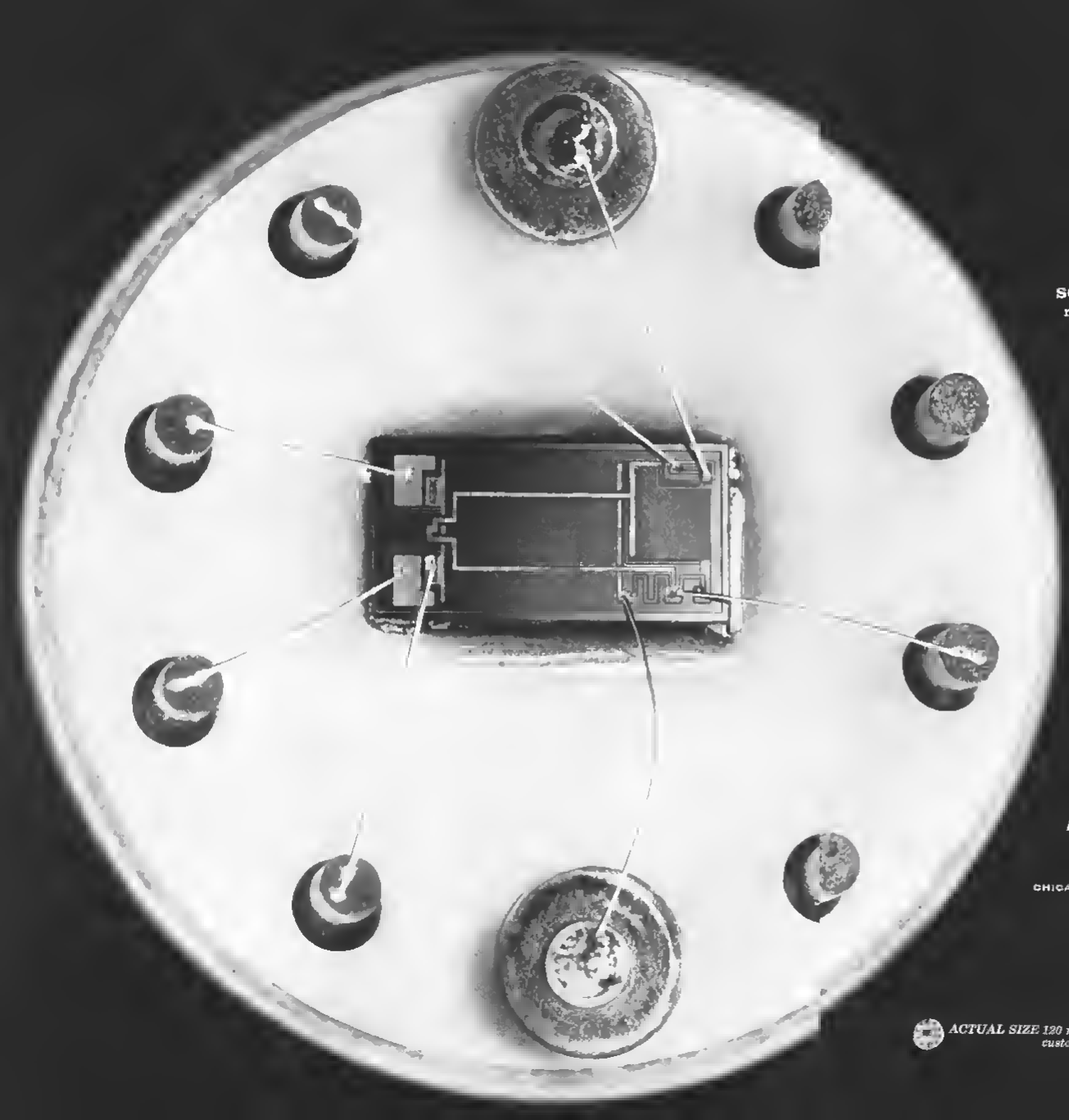

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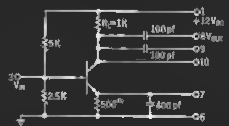
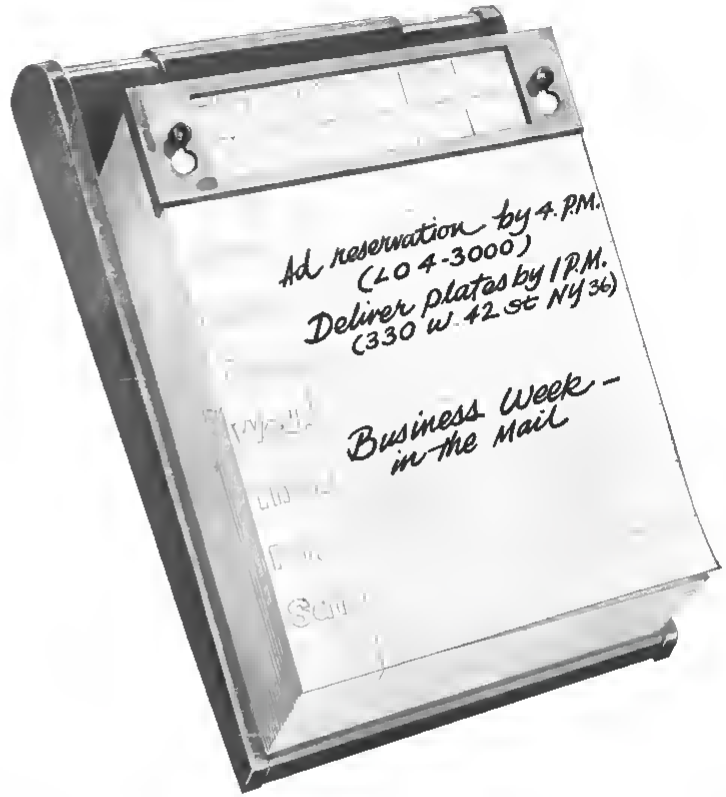
ACTUAL SIZE 120 mc RF high frequency linear amplifier integrated circuit custom built by Motorola's Semiconductor Products Division.





THE YEAR OF THE QUIET SUN

...AND WHAT DOUGLAS IS DOING ABOUT IT

Scientific predictions indicate that solar activity will be at a minimum between July, 1964 and July, 1965. This has been designated as the International Year of the Quiet Sun, and during it a world-wide magnetic survey will take place. □ The Douglas Space Physics and Planetary Sciences Group is studying scientific experiments to be performed on satellite and space probe missions during this period. Instruments to be used will be among the following: magnetometers; ionization chambers; G-M detectors; scintillators; solid state detectors, and spectrometers. □ The present Douglas Antarctica Riometer Station program for the study of cosmic rays will continue through this "Quiet Sun" period and will provide important data relative to solar cosmic ray and auroral events and the geomagnetic K-index. Douglas was invited to participate with the National Science Foundation in this program.

Preparation for the Year of the Quiet Sun world scientific survey is one of more than 500 research projects that are under way at Douglas. Some of these relate to the solution of problems on programs of today and tomorrow. Others range through development and research programs whose effects may not be evident until ten or twenty years in the future.

DOUGLAS

Volume 78
Number 10

Aviation Week & Space Technology

March 11, 1963

THIRTIETH ANNUAL INVENTORY OF AEROSPACE POWER

• COVER USAF Minuteman ICBM is fired from silo at Vandenberg AFB, Calif.

Aviation Week & Space Technology

Aerospace Sales, Earnings to Continue Climbing in 1963

Aerospace industry will continue climbing a rising curve of sales and earnings during 1963. Sales will set a post-war record of more than $16 billion for the year, an increase of more than $1 billion over 1962.

Here is the current aerospace market:

- **Space—$7.3 billion** total earmarked for space technology, of which about $5.7 billion represents the Fiscal 1964 National Aeronautics and Space Administration budget and $1.6 billion the military space budget.
- **Aircraft—$6.4 billion** for procurement of military aircraft from the Fiscal 1964 Defense Dept. budget, plus an estimated $2 billion in commercial aircraft sales ranging from jet transports to lightplanes.
- **Missiles—$4.1 billion** for procurement of military missiles from the Fiscal 1964 Defense Dept. budget.
- **Research and development—$4.1 billion** for military research and development on aircraft, missiles and astronautics, including the bulk of the military space budget cited above.

More of the prime contractors for the second generation of manned space flight operations were picked during 1962 for such major subsystems as boosters, flight capsules, guidance and control systems and communications. Key to space business in 1963 will be finding a spot in the vast network of subcontractors and suppliers that is being formed both for the flight systems and the launch and control facilities that must be designed and built to support the Gemini and Apollo flight missions. In addition, this year will see the preliminary research and development for the third generation of manned space flight missions such as a multi-manned, permanently orbiting space station for both military and scientific purposes, establishment of lunar bases and deep space missions.

The Fiscal 1964 space budget, both civil and military, will get its most critical appraisal by Congress in the five-year history of the program, as the expenditures required soar over the $7 billion mark and almost double over last year.

Although aircraft production still accounts for the largest slice of the aerospace procurement pie, space technology is the technical spearhead accounting for the largest portion of the research and development market, with about $6 billion of the total NASA-military $7.3 billion earmarked for this area. Missile procurement is leveling off at a rate considerably lower than forecast several years ago, due to completion of the initial Atlas and Titan ICBM programs and concentration on the solid-fueled Polaris submarine-launched missile and the hardened silo-launched Minuteman.

Biggest program in space technology is manned space flight, including the Gemini earth orbital rendezvous mission and the Apollo lunar landing project. These two programs account for $3.1 billion of the Fiscal 1964 NASA budget, and have increased from $1.7 billion in Fiscal 1963 and $677 million in Fiscal 1962. Unmanned space flight is the next largest item in the NASA shop window, with $754 million sought for Fiscal 1964 compared with $547 million last year and $389 million in Fiscal 1962. Military space spending will concentrate on Samos and Midas reconnaissance satellite systems, both of which require considerable systems engineering before they become operational, the X-20 (Dyna-Soar) and Gemini manned space vehicles, a satellite inspector system and the Titan 3 booster.

Military market will be dominated by the massive buy programed by the Navy and USAF for the McDonnell F-4B and F-4C, and by USAF for the Minuteman ICBM. The aircraft market continues to hold strong, with USAF and Navy scheduled to contract for $2.5 billion in combat aircraft out of the Fiscal 1964 budget, and an additional $600 million earmarked for military transports. Trainers, modifications aimed at modernizing aircraft already in the inventory and spares procurement account for the balance. Army will buy about $522 million in light aircraft and helicopters.

New aircraft projects that will gain momentum in 1963 include the F-111 (TFX), for which General Dynamics/Ft. Worth and Grumman are organizing subcontracting networks based on an anticipated 1,700-aircraft program; the counter-insurgency (COIN) aircraft and the federally supported supersonic transport.

ICBM procurement will account for about $2 billion, or about half of the total military missile market, with some $1.4 billion to be obligated for continuing Minuteman production and about $600 million earmarked to complete the currently planned Polaris program.

Avionics market continues to become more competitive and increasingly sensitive to budgetary fluctuations affecting many aerospace projects. As the number of competing companies grew and volume production of major avionic systems declined, many avionics companies expanded in search of new markets to boost their sales, creating even more intense competition.

Despite these ominous financial and business signs, the avionics industry is setting a fast pace for new technological developments and the application of these improvements. Microcircuitry, with its great promise of increased system reliability, reduced costs and shrinking equipment size and weight, is starting to appear in newer prototype computers and other aerospace equipment. And with the heavy military commitment to this field, eventual air and spaceborne microcircuit equipment is a virtual certainty.

Optical masers, bionics and self-adapting machines are all areas that promise ultimate technological advances that could alter the face of the industry.

Early ventures into space are uncovering avionic problems as fast as the industry is solving them. The still-unknown hazards of natural and man-made radiation are posing vexing questions for design of power systems, digital circuits and other key avionics equipment. The inability of infrared sensors to properly distinguish targets from background has resulted in a rash of theoretical and experimental studies that are long overdue. Reliability of avionic components and circuits in spaceborne equipment still falls well below what will ultimately be necessary.

Air transport industry will face continuing passenger traffic growth of about 10% in 1963, but will have problems in translating this steadily-rising gross revenue level into increased earnings pending outcome of major merger cases and fare trends.

But airline earning prospects are somewhat brighter for 1963 with indications that an industry net of about $50 million is in prospect, in contrast to about $25 million earnings for 1962 and a heavy loss in 1961.

Civil Aeronautics Board decision in the American-Eastern merger is expected by mid-year, and will shape the trend of the competitive picture. If it is approved, a scramble among the remaining domestic airlines to merge into new competitive patterns can be anticipated. Proposed Pan-American and Trans World merger appears to be sliding farther onto the shelf and probably won't affect the airline picture soon.

Airlines generally are recovering from the worst effects of the jet overcapacity problem and are now facing the bottleneck of an obsolescent traffic control system as a major block toward increased business volume. Slow CAB reaction to the geography of changing U.S. economic patterns is another serious curb on airline efforts to develop new markets, some of which are being exploited by third-level carriers, less inhibited by CAB regulations. Helicopter carriers face increasing difficulties, caught as they are between the operational problems of turbine-powered equipment and the insistence of Congress on reducing their subsidies. Local service airlines face a tough situation in switching to modern equipment with their sensitive subsidy problem.

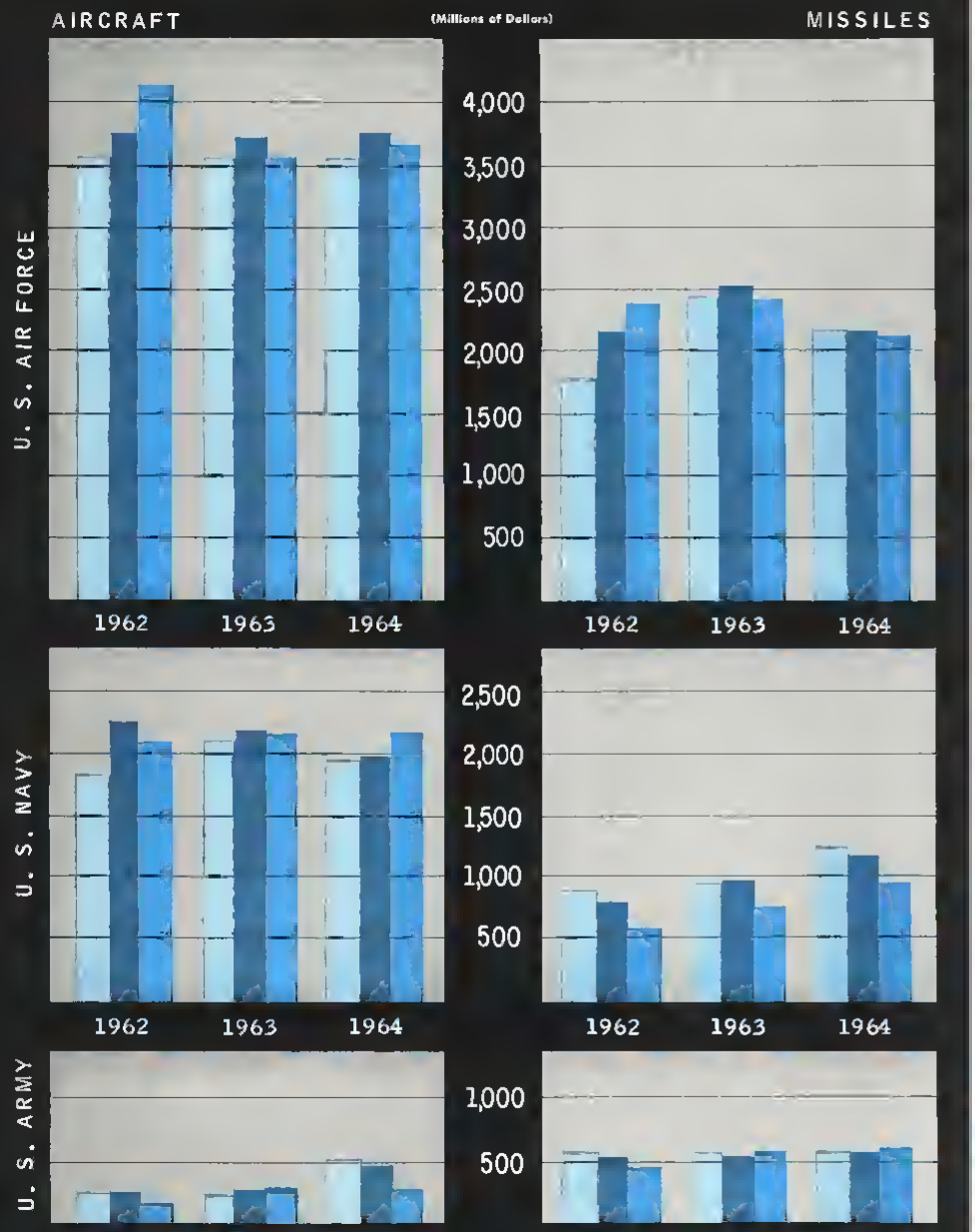
Major trend toward a new fare structure should emerge from the confusion, expense and customer frustration caused by the complexities of airline tariffs. Experiments with single-class service promoted by United Air Lines and the troika rate sponsored by Continental and others should, for the first time, provide some solid operational data on which a badly-needed new and simplified fare structure can be based. Airlines will again be facing major re-equipment problems with the short and medium-haul jet and the jet freighter.

Business flying will continue its upward pace with a gain conservatively estimated at 10-12% over 1962's $180 million volume, and total units delivered will exceed 7,000, compared with last year's 6,697. Emphasis will continue to be on the more sophisticated, multi-engine business aircraft, and three new models are being introduced in 1963 to swell the number of twins on the market to 17. Biggest problem facing the industry is not technology but solving the salesman and dealer shortage, which is holding sales far below potential volumes. Export sales, which now about equal the industry's total sales only a decade ago, also will move steadily upward this year to register a better-than-10% gain over 1962's $40 million.

Although international and domestic politics have always been standard market data for the aerospace industry, it appears that these factors will assume more importance than ever in shaping the course of both commercial and military business during the next several years. The impact of the Kennedy Administration's multilateral nuclear deterrent policy on NATO, its determination to try to confront the Soviet Union with a superiority of conventional military forces and its use of the growing space budget as an economic stimulant for certain areas of the country emphasize the influence of these factors to a degree never before experienced by the industry, short of a major war.

It is ironic that in the face of a post-war record business volume, the aerospace industry also faces trends toward heavy government encroachment into its management prerogatives and technical capabilities, eroding its rewards for superior performance. Solving these government-industry relationship problems, rather than simple salesmanship or engineering prowess, is the toughest industry challenge in 1963. —Robert Hotz

Major Military Obligations and Expenditures



Military

Grumman E-2A (W2F-1) Hawkeye approaching deck of nuclear powered carrier Enterprise. North American A-5A (A3J-1) Vigilante is behind island.

DOD Shifts Stir Ire of Congress, Allies

Washington—Defense Dept policy makers are pushing ahead with their overhaul of defense strategic and procurement structure but now are beginning to reap the inevitable repercussions from the powerful broom they are wielding.

No sign exists that Defense Secretary Robert S. McNamara has lost the firm backing of President Kennedy. But the McNamara team policies have resulted in some outcries in Congress and in other nations

Reaction in the services has been mixed between welcome to changes and to demand for improved performance by the military on one hand, and on the other dismay at the bypassing of military advice.

Negotiations with the North Atlantic Treaty Organization nations, for example, have been carried on largely by McNamara, his deputy Roswell Gilpatric, Paul Nitze, assistant secretary for international affairs, and others of the civilian hierarchy.

The Nassau meeting last December that resulted in the agreement to provide Britain with Polaris submarine-launched ballistic missiles—without warheads or navigation and fire control equipment—was a completely civilian operation.

Major examples of defense policy cause and effect:

• **Defense Dept** succeeded in overcoming differences in Air Force and Navy preferences to initiate development of a common, though not identical, tactical fighter in the TFX program. However, a Senate investigation seems certain to raise prickly questions on award of the contract to a General Dynamics-Grumman team over the other finalist, Boeing Co.

• **Cancellation of Skybolt** demonstrated McNamara's intent to carry into practice the results of DOD's cost effectiveness analyses despite the consequences, political or otherwise. Besides the economic impact on the West Coast, the cancellation stirred diplomatic complications because of the intention of Britain to use the air-launched ballistic missile to extend the life of the Royal Air Force V-bomber force.

• **Defense policy** on nuclear forces for allies of the U.S. erupted into controversy with France which has decided on a go-it-alone nuclear capability. Cancellation of the Skybolt reinforced the French decision that France could not rely on U.S. supplied weapons and France rejected the Polaris offer that Britain took in lieu of Skybolt.

• **Confrontation of Russia** led to success in forcing withdrawal of intermediate and medium range ballistic missiles from Cuba and produced a graphic demonstration of U.S. aerial photo-reconnaissance capability. But handling of the initial Cuban deployment produced friction with the military over command prerogatives, and fumbling of public affairs aspects resulted in confusion and doubt over the achievement.

• **Refusal to spend** extra funds voted by Congress for the North American RS-70 Mach 3 bomber led to continued skirmishing with Congress.

Despite the occasional rumble of thunder, the McNamara team is going ahead with its reorganization and policy changes as briskly as ever.

These include increased emphasis on conventional warfare capability which would include strengthening of Army aviation, reorganization of the Navy's procurement structure, sponsorship of greatly increased use of incentive contracting into early stages of development, and further expansion of single manager agencies in procurement and in other areas.

McNamara's goal of reducing what he terms the proliferation of weapon systems has been amply demonstrated in practice. Besides the cancellation of Skybolt, which McNamara considered too expensive for what it would produce, there have been only three new major aerospace weapon systems started into the development cycle since McNamara's accession 26 months ago. These are the TFX, the mobile medium-range ballistic missile and the Titan 3 space booster—with the Nike X anti-missile missile and a counter-insurgency aircraft as prospective near-term additions.

Even in the case of the new systems, the pace has been extremely deliberate. MMRBM still is in the Phase 1 definition process, and the results of the studies as well as the political situation in the NATO countries where the weapon would be deployed may influence its future. Titan 3, which completed Phase 1 early last spring, still has not reached the formal Phase 2 contract stage for all components, though the process is expected to be completed shortly.

Much of the rationale behind the McNamara policies is economic, both in domestic and international arenas. Among the consequences of this has been a strong emphasis on improved management by the military, and by industry as well.

The only guideline given to the services for Fiscal 1964 budgeting was that

TOTAL military research and development obligational authority is shown for specialized aerospace areas.

they should submit requests for funds which would enable them to meet their force goals "I was particularly anxious that nothing should be done to discourage the military departments from submitting any program change they felt was necessary for defense of the nation," McNamara told the House Armed Services Committee

Budgets the services submitted would have added about $40 billion to the program projections between 1964 and 1967, a result McNamara said was expected because of the lack of ceilings

For Fiscal 1964 alone, budget requests amounted to $67 billion, but as a result of hundreds of analyses and decisions the amount was pared to the final $53.7 billion figure This budget figure, higher than that of the previous year, seems a paradox, what with cancellations and delay in starting new systems, but the explanation is that it represents a realism missing in previous defense budgets

The process of putting a defense budget together was modified to a minor extent during preparation of the Fiscal 1964 requests McNamara and his Assistant Secretary (Comptroller), Charles J Hitch Jr, had instituted the program package approach to defense budgeting in preparing the Fiscal 1963 budget Instead of functional budgets service by service, the requirements were put together by types of forces Strategic Retaliatory Forces, Continental Air and Missile Defense Forces, General Purpose Forces, Airlift/Sealift Forces, Reserve and Guard Forces, Research and Development, General Support, Civil Defense and Military Assistance

Part of the process of budgeting for these principal categories is planning what is needed in each force element for five or more years ahead The original goal of McNamara and Hitch was to have continuous programming so that when budget time approached each autumn little adjustment would have to be made

However, the continuous program change procedures went into effect only last July 1 As a result McNamara had to revert to the system which he had used for Fiscal 1963 which required him to review personally hundreds of changes in a short time and make decisions

McNamara has begun a five-year cost reduction program. Five-year projections make it seem that expenditures can be substantially reduced but as time goes on requirements for new systems keep the spending high McNamara describes this as the "bow wave" effect and calls it unavoidable

But as far as procurement practices are concerned, he feels savings are possible here, and his five-year control program has as its objective the improvement of management practices Goals have been set for the military departments and defense agencies

The program falls into three general categories

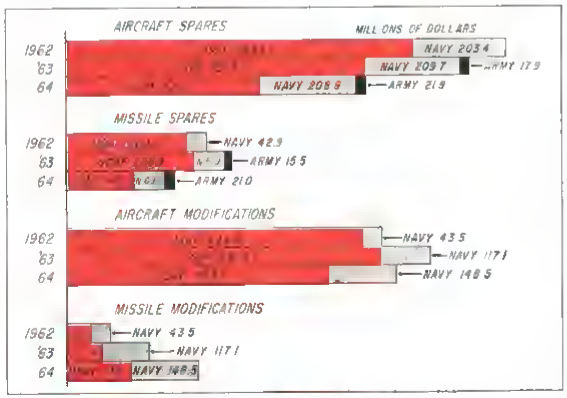
• Coordinating buying with need Refinement of the way weapons and supply requirements are established is under way For instance, one big item of dispute in the past has been how much extra is needed in inventory to allow for pipeline lead time between manufacturer and user—how many spares are needed

There are about four million items in the supply lines now and there is a tendency for each echelon of command to add to the safety margin to take care of D-day needs Inventory controls will be tightened Excess inventories will be used at an increased rate. Excessive system sophistication—"goldplating"—will be fought

• **Buying at the lowest sound price.** Emphasis is being placed on competitive buying For standard production items this is relatively easy, but for complex weapon systems new methods are being tried For one, high value and high usage items are being separated from contracts and opened to bidding instead of buying them from the prime contractor. Fixed price and incentive contracts will be substituted wherever possible for cost plus fixed-fee contracts

• **Reducing operating costs.** A continuous review of bases and property is being conducted So far, McNamara has announced plans to close or reduce 313 activities, of which 71 are located overseas and 242 in the U S About 246,000 acres will be released for non-defense use. Procedures for procurement and paperwork will be simplified

At present the Defense Supply Agency is installing a new system known as MILSTRIP (Military Standard Requisitioning and Issue Procedures)



BUDGET REQUESTS for spares and modifications of aircraft show sharp declines Much lower volume of such business in missile areas has important implications for future business in the aerospace industry

DSA Expansion

The Defense Supply Agency (DSA) has expanded rapidly since its formation By June 30 it will employ about 25,000 persons The headquarters will soon occupy two large warehouse buildings at the Army's nearby Cameron Station supply center at Alexandria, Va., and cataloguing facilities will be located at Battle Creek, Mich.

During the current fiscal year the supply agency will manage an inventory averaging $2.6 billion in value It will make sales to the services of about $3.1 billion while at the same time buying $2.9 billion in new supplies

By July 1, the agency will manage all assigned commodities and services except electronics materiel Electronics management will follow in Fiscal 1964

Historically supply systems have tended to bog down under inadequate and slow information systems The Defense Supply Agency is in the process of automating all phases of supply requisition and distribution in an effort to overcome this obstacle

Standardization of distribution is only in its early stages Each of the services had its own methods of providing logistics to its own activities until last year The Army, for instance, had a number of technical services, each with its own method of buying and distributing The Navy separated its supply system into two parts, one serving the whole Navy with general supplies and the surface Navy with specialized supplies and the other serving the aviation and missile forces. The Air Force has depended on the Army for many of its supplies of a general nature

The development of a general defense catalog as part of the federal catalog system which began in the mid-1950s laid the foundation for a defense-wide distribution system. That action gave common names and numbers to all supplies Now methods to handle the paperwork and actual handling will be standardized

Each of the other three single manager agencies of the Dept of Defense has grown in strength and size in the past year The Defense Intelligence Agency (DIA) has now actually consolidated operations of all of the intelligence and investigative activities of the three services

Defense Intelligence has established closer liaison with the other intelligence activities of the U S, especially the Central Intelligence Agency Perhaps its greatest accomplishment, however, has been the elimination of three separate intelligence estimates based on individual service analysis

Previous administrations had been confronted with intelligence estimates, based on the same sources of information, which differed widely in their conclusions The Air Force, and in particular the Strategic Air Command, emphasized Russian bomber and missile capabilities, The Navy stressed the capabilities of Russian submarines, while the Army did the same with the ground forces of the Communist bloc nations

Another major single manager agency—the Defense Communications Agency (DCA)—plans to cross connect all defense long line communications, both by landline and radio. All long line networks in the continental U S have already been consolidated By the end of 1963 all overseas lines will have been consolidated

The communications agency has a five-year plan to change all communications to automatic switching. Equipment for this is being developed. In the case of leased facilities the agency has taken from the individual services the responsibility for managing, leasing and paying for the facilities originating in the U S

Closely related to consolidated communications is command and control The Administration from President Kennedy down has ordered increased concentration on tying together the control of all of the weapon systems of the U S To a degree greater than ever before the decisions to take specific military actions must originate at higher levels This situation makes necessary rapid communications from the high levels to each military unit

McNamara has revealed the formation of a World Wide Military Command and Control System (WWMCCS), both on a national level and within the military services The National Military Command System (NMCS) is part of the world-wide system This provides the means of furnishing the President and other officials with quick intelligence on what is happening and the means to take action immediately

The National Military Command System also provides for alternate command post locations for the President and others in the national chain of command. This includes hardened buried sites, command ships and submarines, and airborne command posts

Of greatest immediate importance to the President is the control of the use of nuclear weapons Because the nuclear weapon control systems are only partially hardened, the Defense Dept originated an airborne Post Attack Command and Control System (PACCS) It is composed of KC-135 command post aircraft and B-47s equipped as communications relay aircraft This system is almost in complete operation

Command and control, nuclear forces, and economics all were related in Defense Dept's international dealings last year

Of all of the U S commitments overseas, the NATO alliance is considered the most important by McNamara Because of the growing strength of the NATO nations, the U S wants them to assume more of the costs of maintaining forces to counter a Communist bloc land attack When it comes to nuclear forces, McNamara insists that the only way to gain a coordinated response is with an integrated force responsive to a single chain of command and attacking a single set of targets

If the NATO nations want to form a nuclear force, he argues, they must do it multi-laterally, with each contributing according to its ability—but only after meeting the requirements of the conventional forces

Tenor of this U S argument is that the U S has the economic resources to maintain nuclear forces large enough to form a really effective deterrent Weak forces, operating on their own, McNamara says, would be costly and of questionable effectiveness. To satisfy the nuclear ambitions of NATO countries, the U S is offering to cooperate in building a multi-national nuclear force

Many of the ideas on how the NATO alliance should operate, as stated by McNamara and other officials are being influenced by the economy of the United States, especially in relation to the unfavorable balance of payments

To reduce the imbalance, the U S has

• **Signed agreements** with other countries to have them assume a greater burden of defense costs West Germany has agreed to increase its military procurement in the U S and pay for use of U S supplies, depots and maintenance and support A partial support agreement has also been made with Italy Others are being sought, but little hope is held of obtaining any help from the French

• **Shifted procurement** in the U S of goods formerly purchased overseas

• **Limited use** of military assistance funds for offshore procurement

DOD CANCELLATION of the Skybolt air launched ballistic missile, shown here mounted on B-52 wing stirred controversy with Britain

USAF Wages Space, Weapon Fund Battles

By Larry Booda

Washington—Air Force is fighting a funding battle on two fronts—still seeking an expanded and clearly defined space mission, and at the same time, trying to cope with opposition to weapons programs related to its non-space role.

Beginning with Dr. Herbert York, director of Defense Research and Engineering under President Eisenhower, Defense Dept. has resisted Air Force efforts to expand its space mission, and this tendency has been followed by York's successor, Dr. Harold Brown. Their contention is that Air Force proposals for offensive space systems represent more complicated ways to perform a task that can be done by existing missile systems.

In its latest bid for a specific role in space, the Air Force is citing an urgent need for manned anti-satellite systems. Lt. Gen. James Ferguson, USAF deputy chief of staff for research and development, outlined before a congressional committee a minimum Air Force space program, including manned flight requirements. The program covers both offensive and defensive (satellite inspector) systems.

Ferguson told the committee that adequate U.S. space defense depends upon systems for detecting, intercepting and taking action against hostile satellites.

USAF Fiscal 1964 budget requests contain little mention of a space program. The satellite inspector program for determining the function of objects in space is cited. It is also stated that one third of USAF's $330-million request for exploratory efforts will be devoted to space or space-related activities. These funds will cover studies, experiments and component development for guidance, flight control, propulsion, life sciences, surveillance and electronics.

Defense Secretary Robert S. McNamara has said that $1.67 billion is going into military space projects this year. There are indications, however, that the figure is much higher than this, with funds coming from a variety of "cover" sources, such as the Advanced Research Projects Agency and other research activities.

One space-related project which is nearing the development stage is the Titan 3 space booster. This multipurpose vehicle was first envisioned to inject the Dyna-Soar boost-glide vehicle into a low orbit. Now it is being mentioned for such projects as military communications satellites, Gemini-type spacecraft and a manned orbital development station (MODS).

There is some doubt that the Dyna Soar project will be permitted to continue by McNamara (AW Feb. 25, p. 26). Air Force hoped that this program would be the first step in gaining experience for military missions in space.

Another USAF concept, the Aerospace Plane, is progressing steadily through development of components. Aerospace Plane would be a single stage-to-orbit vehicle using liquid oxygen and liquid hydrogen propulsion. In the atmosphere it would have a hypersonic capability. Outside the atmosphere it would act like a spacecraft. One concept would have it gather its own oxygen supply for liquefaction and storage for later use in space.

Air Force has also met cutbacks in other proposed weapon systems. McNamara has declared that the proliferation of weapon systems must be stopped. He has also said, as recently as Feb. 28, that estimates of weapon costs must be more realistic. Of more than a dozen systems he studied, the secretary said, most were at least 300% over original estimates of total program costs, and one was 1,000% higher.

One of two major actions taken by McNamara was cancellation of the Skybolt air-launched ballistic missile, which not only dealt a blow to USAF hopes for continued use of Boeing B-52 bombers into the 1970s, but also caused the British to change their plans for large manned bombers. Great Britain had been counting on Skybolt for its V-bomber force.

In addition, McNamara has impounded most of the additional funds voted by Congress for the North American B-70 Mach 3 bomber, keeping the program within a $1.3 billion limit, except for an additional $50 million recently released.

The manned nuclear bomber force will be reduced by six Boeing B-47 wings between Jan. 1 and July 1, 1963. This will be offset, according to McNamara, by an increase in deployed ballistic missiles, particularly solid-propellant Minuteman ICBMs.

Tactical fighter forces, in line with the Kennedy Administration's emphasis on conventional war forces, will increase considerably. Delivery of the McDonnell F-4C fighters will expand substantially before the end of the year.

As a result, the Air Force pilot training program will increase in Fiscal 1964. At present it is below that of the Army for the first time. By Fiscal 1965 about 2,500 USAF pilots will enter flight training per year.

All USAF/General Dynamics Atlas intercontinental ballistic missiles, a total of 126 in 13 operational squadrons, are in place. Martin Titan I ICBMs are completely deployed, and all Titan 2 missiles will be in place by the end of 1963. Boeing Minuteman missiles will be entering their underground launch silos at an accelerated pace by the close of this year.

Plans have been made to phase out Atlas D models because their unhardened, above-ground pads will be vulnerable by 1965. McNamara has retained the option to phase them out more quickly or more slowly, however.

Titan 1, fueled with liquid oxygen and fired after being raised from a hardened silo, is in six squadrons, each with nine missiles. Another nine squadrons of Titan 2 missiles, whose liquid fuels are storable and which are fired from within silos, will make a total of 108 Titans on launchers.

A total of 800 Minuteman missiles has been planned through Fiscal 1963, all of which should be in place by the end of Fiscal 1965. There are 30 of these missiles now in place. Three squadrons totaling 150 missiles are planned to be operational by July 1, 1963. Minuteman program would be increased by 150 missiles for a total of 950 under fund requests in the Fiscal 1964 budget.

Work on improving the Minuteman is going ahead under high priorities. The missile has been unable to fly as far as its operational mission requires. This is being corrected by using lighter-weight materials for first and second stage casings, boosting the propulsive force of the propellants and increasing the amount of propellants.

Air Force is engaged in exploratory and advanced development of future strategic missiles which will offer high destructive yield at lower cost. The mobile mid-range ballistic missile (MMRBM) is also the responsibility of the Air Force.

Intensive study program phenomena surrounding re-entry of ballistic missile nose cones is under way. Although the work was initiated in the South Atlantic during early tests of ballistic missiles it wasn't until there was sufficient technology available to provide terminal guidance for the nose cones that greater funding was provided for the program.

Systems have now been devised to

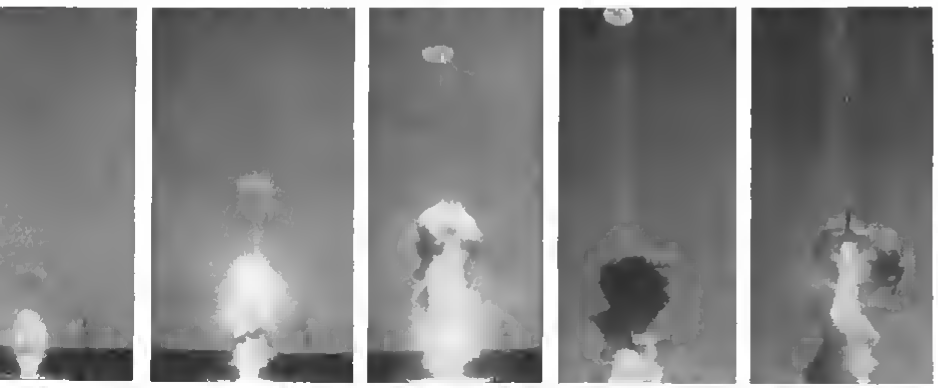
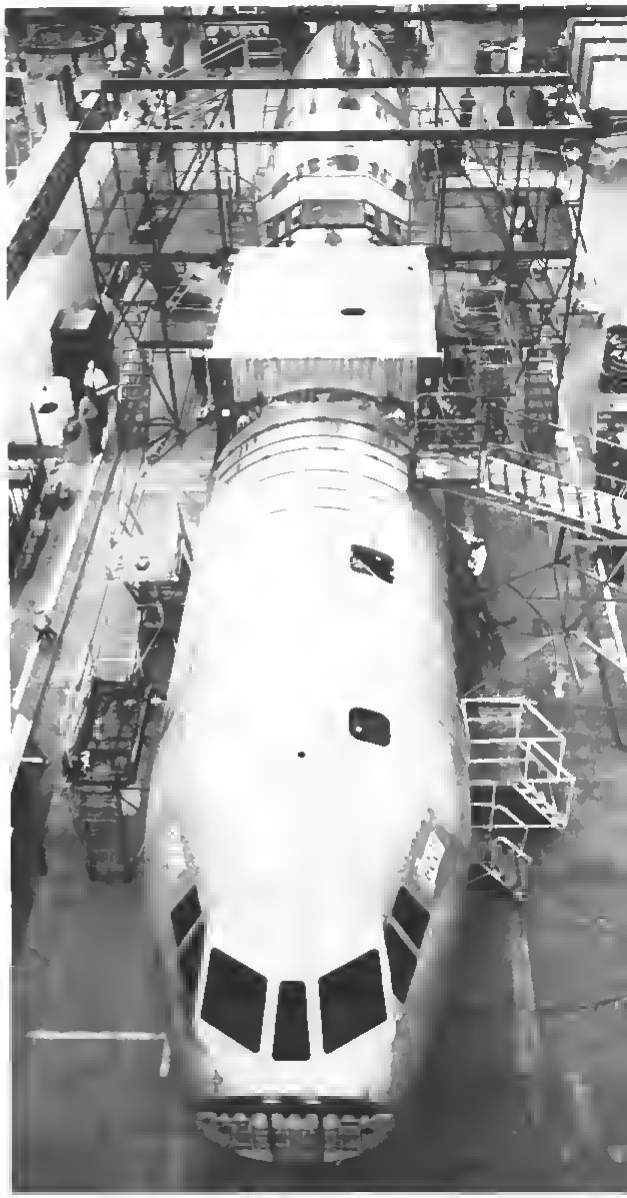


PHOTO SEQUENCE shows USAF Minuteman intercontinental ballistic missile silo-launched from Cape Canaveral, Fla.



MATING OF FUSELAGE subassemblies for the Lockheed C-141 turbofan cargo transport has been completed at Lockheed's Marietta, Ga. plant. Transport will be powered by P&W TF 33 P-7 turbofan engines.

maneuver nose cones and eject decoys. Some means of command for the re-entry period is desirable if this is to be done.

Other penetration aids are also being studied. Means to transmit through the plasma sheath surrounding nose cones with radio or by other emanations are being considered. This is the same phenomena which has caused communications blackouts with the manned Mercury capsules during re-entry periods.

McNamara is now facing congressional committees inquiring into the Fiscal 1964 defense budget requests. Questions about the future of manned nuclear bombers have been frequent, especially in the Senate.

McNamara compared the vulnerability of B-52 bombers with that of Minuteman and Polaris missiles. The B-52s, he said, are "soft"-based at about 60 locations. Deployment of additional Polaris submarines, which offered concealment, and Minuteman ICBMs in hardened and dispersed sites has given the U.S. a balanced and protected force. This led to a decision to stop B-52 production.

He brought the RS-70 strike-reconnaissance version of the B-70 into the argument. By the 1970s, he said, the skies over Russia will be untenable for manned bombers because of improved anti-aircraft defenses, including surface-to-air missiles and fighter aircraft. McNamara did not counter Air Force arguments for the RS-70 as a post-strike reconnaissance aircraft to spot targets which have not been destroyed and those whose location was not known. But at no point in his congressional testimony did he mention other means of gaining reconnaissance information.

Air Force Active Aircraft Inventory

1958	22,578
1959	20,890
1960	18,712
1961	16,905
1962	16,591
1963 (Estimated)	15,567
1964 (Planned)	15,446

As for air-launched ballistic missiles, he said the RS-70 would provide only a very small increase in over-all effectiveness by carrying such weapons. It is not worth an additional outlay of $10 billion for aircraft and missile development over the $1.35 billion already approved, he noted.

McNamara explained the cancellation of the Skybolt missile by saying that it combines the disadvantages of the missile with those of the manned bomber (AW Feb. 11, p. 67). The manned bomber is "soft" and concentrated on the ground and has a relatively slow time to the target or firing area. The missile would not have the bomber's usual heavy payload and accuracy, he said. "It would have the lowest accuracy, reliability and yield of any of our strategic missiles, without the relative invulnerability and short time to target of a Minuteman or a Polaris," the secretary stated.

Skybolt is tied inflexibly to its carrier, the B-52, McNamara added, and thus must be committed to a target early in a war. Polaris missiles can be "locked in" and used by the President as needed, he said. Minuteman and Hound Dog can perform the task of target suppression, he explained.

McNamara plans to phase all B-47 aircraft out of service by 1965. Two wings of the supersonic General Dynamics B-58 jet bombers, about 95 aircraft, will be kept in the force through at least 1968. Fourteen B-52 wings, about 700 aircraft, will remain for the same period of time. He offered no manned aircraft successor.

Role of the tactical, conventional weapon-carrying aircraft in the Air Force is increasing. It was not by choice of the Air Force, however, that this trend began. Under the Eisenhower Administration, tactical aircraft in the inventory, such as the F-84, F-100 and F-105, were configured for delivery of small nuclear weapons and little else.

When the Kennedy Administration began to emphasize the need for strengthening conventional war forces, the Air Force was instructed to buy the F-4C twin-engine aircraft developed by the Navy.

Now the Air Force will buy more of this type of aircraft than the Navy and Marine Corps. The Tactical Air Command will remain at a 21-wing strength level, but its North American F-100s will be phased out sooner than originally planned.

Since the Republic F-105s will remain in the force they are undergoing a major modification program to carry and deliver conventional weapons. Their guidance systems must be changed, wiring replaced and means of carrying bombs, rockets and napalm tanks installed.

Procurement of the F-4C will last until the new F-111A (TFX) variable geometry-wing tactical fighter is developed and produced. The F-111A was subject to a long period of dissension as to whether it could serve the needs of both the Air Force and Navy. The program then was opened to industry proposals. When six proposals were received a decision was reached to choose two finalists instead of a winner. These finalists, General Dynamics-Grumman and Boeing, conducted prolonged definition studies, receiving payment for their effort. General Dynamics-Grumman was selected 16 months after the requests for proposals had been issued.

Reconnaissance for tactical forces will become a function of the reconnaissance version of the F-4C, the RF-4C. It will replace the RB-66 and the RF-101. To increase the immediate needs of the regular tactical forces for this mission, the Air Force will transfer some Air National Guard and USAF Reserve RF-84s to TAC.

Air Force will purchase a number of tactical weapons in line with its increased emphasis on tactical warfare. Falcon air-to-air missiles, with both conventional and nuclear warheads, will continue to be added to the inventory. Also, the Air Force will buy some Sparrow 3 air-to-air missiles. Another weapon in the air-to-air category will be the infrared seeking Sidewinder.

Standard air-to-surface missile will be the Bullpup sight-guided system. Some conventional armament will be purchased, particularly smaller bombs of several types. These purchases were temporarily jeopardized last fall when McNamara decided not to allow such purchases by the Air Force, Navy and Marine Corps. He later changed the ruling after receiving strong protests from the services.

Portable control centers will be purchased for USAF field use to control operations of the newer fighters whose fire control and other combat systems are more sophisticated.

Air defense strength of the Air Force will decline in size over the next few years. McNamara foresees a reduced Soviet bomber threat. No new procurement of fighter aircraft is planned to add to the present inventory of F-101, F-102 and F-106 aircraft. In a time of emergency these could be augmented with about 500 Air National Guard aircraft and Navy and Marine Corps airplanes temporarily based in the continental U.S., Canada also furnishes fighter interceptors.

Bomarc surface-to-air missile will remain in the force for several years because the development cost is already written off. The Bomarc is a winged missile launched with a solid-propellant booster and then powered in flight by a ramjet engine.

North American air defense is augmented by the Army's Nike-Hercules surface-to-air solid-propellant missile.

North American Air Defense Command (Norad), along with its Air Force element, the Air Defense Command, has had its mission broadened to include warning against ballistic missile attack. Two Ballistic Missile Early Warning System (BMEWS) stations are operated by the Air Force at Clear, Alaska, and Thule, Greenland. A third station will become operational at Fylingdale, England, during the next fiscal year.

Bomb alarm system which would reveal if a nuclear explosion occurred at or near one of these sites is in operation.

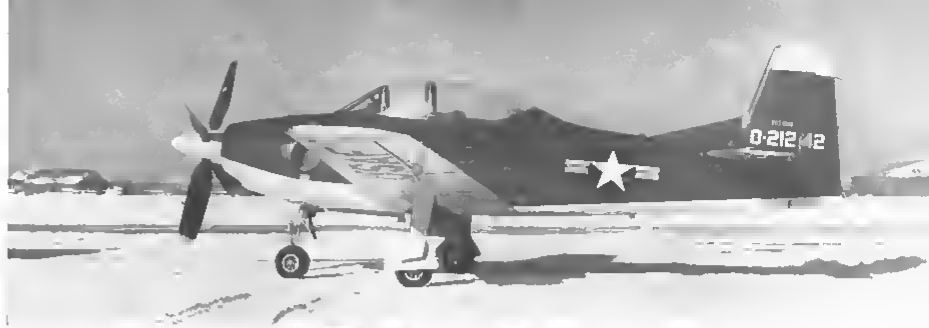
Norad is the focal point for the Space Detection and Tracking System (Spadats). This system has the task of detecting and tracking all objects in orbit around the earth. It is a combination of the Navy's Space Surveillance System, the Air Force's Spacetrack and optical sighting stations operated by a variety of agencies. Navy's Spasur has been the principal means of detecting new and unannounced objects so far.

Air Force Aircraft on Order

Aircraft Type	Popular Name	Manufacturer
F-4C, RF-4C	Phantom 2	McDonnell
C-130E	Hercules	Lockheed
C-141A	StarLifter	Lockheed
F-105D	Thunderchief	Republic
RS-70	Valkyrie	North American
T-38A	Talon	Northrop
C-135B	Stratolifter	Boeing
F-111A	Not Assigned	General Dynamics/Grumman
CH-3C	Not Assigned	Sikorsky

Air Force Missiles and Space Vehicles on Order

Missile or Vehicle	Mission	Manufacturer
Minuteman	ICBM	Boeing
Titan 2	ICBM	Martin
Bullpup	Air-to-Surface	Martin
Sidewinder	Air-to-Air	Philco
Falcon 9, 11	Air-to-Air	Hughes
Sparrow 3	Air-to-Air	Raytheon
Agena D	Multi-Purpose Upper Stage Space Vehicle, Launched by Thor and Atlas Boosters	Lockheed



TURBOPROP VERSION of the North American T-28 is designed for counter-insurgency operations. Designated YAT-28E, it is powered by a Lycoming T55 engine and can carry 50-cal. machine guns, bombs and rockets in various underwing store combinations.

STOL-MODIFIED C-130R HERCULES is being tested as part of USAF's growing emphasis on tactical close-support operations in forward military areas. Transport has been modified to give the aircraft rough-field landing and takeoff capabilities.

LATEST of the North American A 5 family is the A 5C reconnaissance version. Belly pod houses sensing devices.

CRUISER USS ALBANY successfully fires a Tartar and two Talos missiles simultaneously, Navy's first such launching.

Navy Faces Reorganization of Forces,

Washington—Overhaul of the Navy's procurement structure to place applied research, development, production and logistics under one or two commands, in preparation for the last year, now is approaching actuality and needs only the approval of Secretary of Defense Robert McNamara to begin.

A second fundamental reappraisal faces the Navy in its missions and force structure and studies are under way on nuclear power for large ships and on the cost effectiveness of large aircraft carriers and fleet air defense systems.

Procurement in the Navy has been a split responsibility. General supplies have been the responsibility of the Bureau of Supplies and Accounts. Specialized procurement—including weapon systems—has come under the technical bureaus such as the Bureau of Weapons, the Bureau of Ships and the Bureau of Yards and Docks. Each bureau manages its own applied research, development, production and logistic support.

For the reorganization, the Navy is proposing alternate structures resembling either those of the Air Force or the Army. The Air Force has two commands, one for applied research, development and production, and another for logistics. The Army has combined all of these functions into one command.

In addition, the bilineal structure of the Navy will be abolished. The Navy has been organized as two pyramids, in effect, one stemming from the Secretary of the Navy, the other from the Chief of Naval Operations. All of the technical bureaus report directly to the secretary and the Chief of Naval Operations has no cognizance over them. The Chief of Naval Operations has jurisdiction over the operational forces and the establishment of requirements. Only the Deputy Chief for Development cuts across lines to the secretary's organization.

In the new organization, a single pyramid would stem from the secretary to the Chief of Naval Operations, whose power would be considerably enhanced.

At present the office of the Secretary of the Navy is a large organization, mostly staffed by civilians. This is the administrative machinery needed to run the bureaus and it is more than three times the size of the staffs of the Secretary of the Air Force and the Secretary of the Army. Under the new organization plan, this office would be drastically reduced and the functions transferred to the new command or commands.

Any reorganization of the operating forces is concerned with a longer time period, to 1980 and beyond. Studies now going on to determine whether the forces of the Navy should remain essentially as they are or be radically changed were kicked off when Secretary McNamara informed the Navy that he was going to withhold the $210 million appropriated by Congress for CVA-67, a conventionally powered aircraft carrier.

Big carrier advocates within the Navy are seeking authorization for a carrier every other year. Because of cost, they decided to ask Congress for an oil fueled ship instead of a nuclear powered one in Fiscal 1964.

Vice Adm. Hyman Rickover, at whose insistence the nuclear powered submarine program was started, has objected to having the Navy buy any more conventionally powered large ships.

He was overruled last year on the carrier power question but last fall he convinced McNamara that only nuclear power would be logical for an aircraft carrier. McNamara ordered the Navy to study ways to use nuclear power at lower cost.

As the study progressed, McNamara became more critical of the cost effectiveness of the large carriers and their aircraft.

The study was broadened to include all carrier forces.

Then McNamara questioned whether it was worth the cost to protect the fleet from air attack, using both aircraft and long-range surface-to-air missiles. He was especially critical of the Typhon missile system, which would require a highly sophisticated radar installed in a ship with minimum displacement of 8,000 tons. Thus the studies were further broadened.

In his comprehensive statement early this year to the House Armed Services Committee, McNamara suggested that developments in vertical-takeoff-and-landing aircraft could alter ship requirements in the future. He also questioned whether it was worth defending the fleet from air attack at all.

Some Navy officers believe that enemy submarine capability in the 1970s will be so great that it will not be possible to defend conventional ships from them. For this reason, they argue, surface vessels should be altered radically in design. Hydrofoil and air cushion vehicles have been mentioned, both for general use and as aircraft carriers. Increased emphasis is urged on air surveillance of the sea.

Largest Navy weapon system program continues to be the Polaris program. At present 41 missile launching submarines have been authorized and with the $695 million requested in Fiscal 1964, the program will be fully funded. Nine Polaris submarines were deployed last year and nine more will be next year.

The first five submarines were equipped with the 1,200 naut mi Polaris A1 missile. The sixth submarine, originally planned for fitting out with the A1, was modified to accommodate the A2, a 1,500 naut mi missile. The sixth through eighteenth submarines will be equipped with the A2. The nineteenth submarine, originally to take the A2, will have the 2,500 naut mi A3.

Remainder of the submarines will be equipped to fire the A3 and eventually the earlier submarines will be retrofitted for this version. In the case of the first five, the tubes will have to be replaced. Alterations in all cases will be made when the submarines enter yards for major overhauls.

The 41 Polaris submarines will require six tender ships, six resupply ships and several floating drydocks and other support ships. Several of the Lockheed C-130E aircraft being purchased by the Navy, principally for the Marine Corps, will be used to ferry Polaris crews to their Atlantic and Pacific home bases.

Logistics facilities are being built at Bangor, Wash., for Pacific-based Polaris submarines. A training facility will be established at Pearl Harbor, Hawaii, and an overhaul facility at Puget Sound, Wash. A tender anchorage will be established at Guam, matching the anchorage at Holy Loch, Scotland.

The Navy also intends to deploy Polaris submarines to the Indian Ocean. The anchorage for submarines based there will probably be near Perth, on the northwest coast of Australia. This area of deployment will not be in use until 1965 or 1966, however.

Life expectancy of aircraft carriers will have its greatest effect on the carrier anti-submarine warfare forces. By 1970, all of the Essex-type carriers now being used for ASW will be 25 years old or older. New ASW carriers are planned to displace 35,000 tons instead of the 40,000 tons of the Essex class. They would be slower and would cost less to operate.

This is assuming that conventional carriers continue to be built for the ASW mission. McNamara has suggested that manned helicopters could be operated from ships the size of destroyer escorts, and development of such ships would reduce the number of carriers needed. Radical changes in the character of the ships needed also could be made with the development of new types of aircraft.

Much of the Navy's effort in anti-submarine warfare research and develop-

Navy Active Aircraft Inventory

1958	10,553
1959	9,649
1960	8,863
1961	8,793
1962	9,176
1963 (Estimated)	8,807
1964 (Planned)	8,860

Fiat G91T

ONE AIRCRAFT ONLY, THREE BASIC USES: TRAINING, OPERATIONAL TWO-SEATER, CLASS MACH 2 PILOTS TRAINER

It is designed for the training of fighter pilots from the initial to the final stage and can perform all the tactical ground support missions planned for the Fiat G91 LWT fighter from which it derives (configuration T/1 and T/3). It can accommodate all the electronic equipment of the F 104G to adequately train pilots assigned to aircraft of this class. It is possible to shift from one mission to another easily and quickly as the aircraft is structurally pre-arranged for the installation of the equipment for the different configurations.

F 104 G

In the light of the European production plan, Fiat, as chief commissioner for Italy, manufacture under license the F 104G aircraft together with the G.E. J79 engine

Fiat Aviazione Corso Giovanni Agnelli 200, Torino (Italia)

ment centers around detecting the deep running submarine operating at 200-800 ft. at slow speed. A snorkeling Diesel powered submarine is relatively easy to detect with radar. It also makes a lot of noise and can be picked up by various types of sonar and sonobuoys. This type of submarine does not run at great depth and can be spotted by passive and active sonar systems.

A nuclear powered submarine running at high speed also makes a lot of noise. The noise comes mostly from pumping machinery on board which takes care of cooling the reactors, and not from propellers. But when a nuclear powered submarine is running deep and slow, the detection problem is greatest.

For some years the Navy has been seeking detection techniques other than sound. One of these systems, which the Navy calls exotic, involves infrared detection of the wakes of submarines. No matter how deep a submarine runs, it leaves a wake caused by its motion and the heat it generates, wakes differing in temperature from the surrounding water by half a degree to as high as a degree.

Another system makes use of very long radio waves which exist naturally in the atmosphere and ionosphere. They are generated by lightning, which is estimated to occur about 30 times per second around the world.

Other systems involve electrical, magnetic and electromagnetic phenomena which are not yet fully understood. General programs on undersea research are titled Trident and Artemis.

The Navy's only major venture in space, the Transit navigational satellite, is due to become operational in 1965. It will provide ships with the ability to determine their position within one tenth of a mile. The operational system will consist of four satellites in polar orbits, four ground tracking stations, a computing station, two injection stations and shipboard decoding equipment.

Launches will be scheduled until there are four working satellites properly spaced in orbit. After achieving operational status, standby launch provisions will be made to replace any satellites which fail or decay.

The aircraft buy for the Navy and Marine Corps, the latter funded in the Navy budget, includes the McDonnell F-4B twin engine two seat fighter, the Grumman A-6A two seat twin-engine attack aircraft, the Vertol CH-46A medium assault helicopter, the Bell UH-1E light helicopter, the North American A-5C twin-engine two seat attack aircraft that will be purchased as an advanced reconnaissance vehicle, the Grumman E-2A combat intercept aircraft, the Sikorsky S-2E and the Lockheed P-3A long-range ASW aircraft.

The Marines will receive the C-130E for troop transport. A training version of the Grumman Gulfstream transport, the TC-4B is on the buy list. So is the C-2A carrier transport version of the E-2A. A jet trainer, the North American T-2B, completes the list.

In new aircraft, the Navy participation in the F-111 (TFX) competition for a variable geometry wing tactical fighter will result in purchase of 235 General Dynamics/Grumman F-111B aircraft.

The Grumman A-6A involves a concept of low level economical cruise along with high load carrying ability. The entire system is built around low level operations in all weather.

Key piece of equipment in the system is a display tube in front of the pilot which can act as a television tube, as a radar scope and, in instrument conditions, superimpose a moving grid system over radar images to simulate ground movement. A sophisticated central air data center and fire control center are tied together to provide the ability to attack over all kinds of terrain and in any kind of weather.

The A-6A will definitely be procured for the Marine Corps, but there has been no definite commitment for use by the Navy, although it was originally designed for carrier operation.

The North American A-5C as a reconnaissance aircraft will be capable of feeding its data from a number of sensors, including cameras, back to control centers in addition to storing it on board for further analysis after return. The A-5C might become the standard medium reconnaissance aircraft for the Air Force, depending on its demonstrated performance.

The Grumman E-2A will fill the need of controlling distant fighters on intercept missions. This it will do automatically, without voice transmissions.

Navy will continue to procure the McDonnell F-4B and RF-4B fighter and reconnaissance versions of the twin-engine two-place aircraft that will become standard in the inventory of the Air Force as well. Navy will eventually replace the F-4Bs with the F-111A developed in the TFX program.

Navy Missiles and Space Vehicles on Order

Missile or Vehicle	Mission	Manufacturer
Polaris A2, A3	Subsurface-to-Surface	Lockheed
Typhon	Surface-to-Air	Bendix-McDonnell
Phoenix	Air-to-Air, For F-111B	Hughes
Sparrow 3	Air-to-Air (Radar Guided)	Raytheon
Shrike	Air-to-Surface	Texas Instruments
Bullpup	Air-to-Surface	Martin
Sidewinder	Air-to-Air (Infrared Guided)	Philco
Tartar	Surface-to-Air	General Dynamics & Applied Physics Laboratory
Subroc	Subsurface-Air-Subsurface	Goodyear
Sea Mauler	Surface-to-Surface and Subsurface, Short Range, Version of Army Mauler	General Dynamics
Hawk	Surface-to-Air	Raytheon
Transit	Navigation Satellite	Applied Physics Laboratory

Navy Aircraft on Order

Aircraft Type	Popular Name	Manufacturer
F-111B	Not Assigned	General Dynamics/Grumman
C-2A	Not Assigned	Grumman
F-4B, RF-4B	Phantom 2	McDonnell
E-2A	Hawkeye	Grumman
A-4E	Skyhawk	Douglas
A-6A	Intruder	Grumman
A-5C	Vigilante	North American
S-2E	Tracker	Grumman
P-3A	Orion	Lockheed
C-130E	Hercules	Lockheed
U-8F	Not Assigned	Beech
T-2B	Not Assigned	North American
TC-4B	Gulfstream	Grumman
CH-46A	Sea Knight	Vertol
UH-1E	Not Assigned	Bell
SH-3A	Sea King	Sikorsky
CH-53A	Not Assigned	Sikorsky

ARMY UH-1A armed escort helicopters, some mounting 2.75-in. rockets, take off for mission in Vietnam.

Army Seeks Greater Mobility in Added

MARTIN PERSHING selective range artillery missile is entering field service with Army.

By George C. Wilson

Washington—Army is entering an era of emphasis on mobility in U. S. national defense that will place increased demand on the engineering and research skills of the U. S. aerospace industry.

Kennedy Administration military strategy calls for an Army which can move fast and hit hard. This concept dictates wider use of both fixed-wing and rotary-wing aircraft as well as dependable nuclear weapons which are easy to carry and fire.

Gen. Earle G. Wheeler, Army chief of staff, sums up this philosophy by quoting Lt. Gen. Richard S. Ewell of Stonewall Jackson's old Corps: "The road to glory is traveled with little baggage." On Defense Dept.'s assumption that the U. S. and Russia are approaching a nuclear stand-off, the Army takes on added importance as the spearhead for conflicts short of an all-out war. Defense Secretary Robert S. McNamara said that during the Cuban crisis "non-nuclear forces were our sword, our nuclear forces were our shield."

This hard-hitting and highly mobile Army the Administration is building was recommended by Gen. Maxwell D. Taylor who retired as Army chief of staff before President Kennedy took office. President Kennedy named Gen. Taylor as White House adviser and then as chairman of the Joint Chiefs of Staff. Gen. Taylor undoubtedly has been partly responsible for the Army's enlarged role in the U. S. military program.

McNamara has told Congress that general purpose forces which include most of the Army's combat and combat support units, "must be prepared to meet a wide variety of contingencies, ranging from counter-insurgency actions to large-scale wars, anywhere in the world. Accordingly, they must be provided with a great variety of capabilities, weapons, equipment, supplies and training."

To support this philosophy, the Defense Dept. is allocating a bigger share of the service dollar to the Army—at the expense of the Air Force. Total obligational authority of the services in the Fiscal 1964 budget is Army 27%, Navy 31%, Air Force 42%. This compares with allocations of Army 24%, Navy 30%, and Air Force 46% in the Fiscal 1961 budget, the last one prepared by the Eisenhower Administration without being reviewed by the Kennedy Administration.

This combination of a new blueprint for the Army plus the money to carry it out presents new challenges and opportunities for the aerospace industry in several areas, including:

● **Aircraft.** Army wants to integrate aircraft into its combat forces to provide more protection and mobility for troops. The idea is to make the use of aircraft as commonplace as the use of trucks. The demand is for aircraft that can operate from short, rough landing areas, and easy maintenance is another objective. Helicopters are especially attractive to today's Army planners for clearing the way for troops and for landing them in forward areas. Fixed-wing aircraft have major roles to play in observation and troop transport.

● **Armament.** Fiscal 1964 will hasten the development of armament for both helicopters and fixed-wing aircraft. Army first wants to build better firepower into its aircraft by using a combination of existing weapons. Next phase is to design weapons from the start for use on helicopters and slow-speed, fixed-wing aircraft. Ultimately, the Army most likely will buy new airframes and weapons systems developed especially for limited war missions.

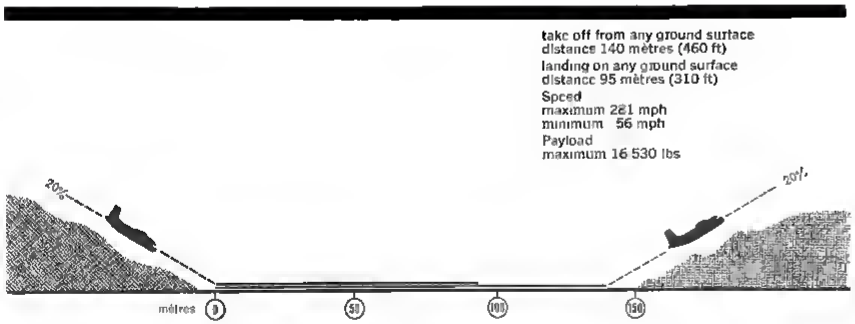
● **Tactical missiles.** Simplicity, dependability and power are the objectives Army is looking to industry to develop a new generation of field weapons which do not require bulky electronics equipment or technical experts to fire. They must also be small enough to be easily transportable by fixed-wing aircraft and helicopters.

● **Anti-missile missile.** Army's work on Nike Zeus virtually assures the service of a continued role in this development effort. Defense Dept. has broadened the research program in quest for an effective weapon against enemy missiles and will support a new relatively low altitude intercept system called Nike X.

● **Navigation equipment.** Emphasis on Army aircraft puts stress as well on ad-

BOEING VERTOL CH-21 is escorted in Vietnam by Bell UH-1A. Terrain, including intake clogging grass, is graphically shown below.

Air Capability



BREGUET 941 STOL the most advanced design so far proposed and developed to solve the problem of short take-off and landing

vanced navigation systems especially for night missions. Army wants a simple but effective system to broaden the capabilities of assault helicopters and fixed-wing observation aircraft.

• **Mobile vehicles.** Army's decision to concentrate on mobility brightens prospects for such advanced vehicles as ground effect machines, although GEMs for the moment have been all but eclipsed by helicopters. But the Army Transportation Research Command feels GEMs have potential for taking large numbers of troops from ships and carrying them far inland over rough terrain.

Aircraft Mix

Army's Fiscal 1964 budget illustrates better than any statement to date just what type of aircraft mix the service is seeking. With the $522 million in new funds sought for Fiscal 1964—$33.8 million of that for spare parts—the Army will buy 1,600 aircraft. This procurement is a big step toward the goal of consolidating present Army aircraft into seven basic types: light observation helicopters, combat surveillance fixed-wing aircraft, utility/tactical transport helicopter, heavy transport helicopter, light utility fixed-wing transport, heavier STOL fixed-wing transport, aerial crane. Details on these seven types:

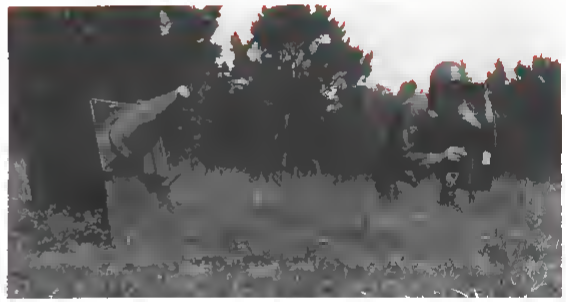
• **Light observation helicopter.** Army will buy Bell OH-13 Sioux and Hiller OH-23D Raven helicopters. But these observation aircraft, along with the Cessna O-1A Bird Dog, will be replaced eventually by a standard light observation helicopter now under development. Bell, Hiller and Hughes Aircraft are all competing in the LOH program. Army plans to use $1.2 million in research funds on the LOH this fiscal year and $100,000 in Fiscal 1964. One of the three helicopters being developed is scheduled to be selected for production but some industry sources predict a split program. The three companies are building five helicopters each and they will be tested by the Army this year. Contract award probably will follow next year.

• **Combat surveillance.** Army in Fiscal 1964 will buy additional Grumman OV-1B Mohawks and plans to make the aircraft its standard one for combat surveillance for the next few years. Currently, the Army is testing three V/STOL concepts in research for an aircraft to follow the Mohawk now in production. One is augmented thrust on the Lockheed XV-4A Hummingbird. A second is the fan-in-wing system in the General Electric-Ryan XV-5A. The third is vectored thrust in the British Hawker P.1127. Army funding of $10 million on surveillance aircraft research and development is planned in Fiscal 1964, and selection of

Army Aircraft R & D

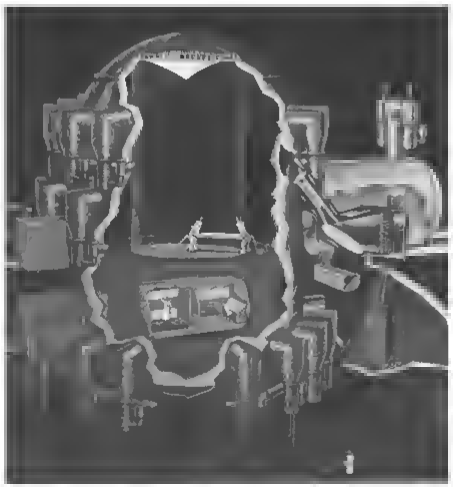
Increased emphasis the Army is placing on armed aircraft generally and a new attack helicopter specifically is illustrated by these figures. First column is the Fiscal 1963 aircraft research and development budget as originally planned. The second shows current planning as a result of reprogramming of funds. Third column is Fiscal 1964 money requests now awaiting congressional approval.

Research Project	New Obligational Authority Requested		
	Original FY 1963	Current FY 1963	Fiscal 1964
Weapon development	$10,000,000	$9,500,000	$23,000,000
Armed attack helicopter		3,000,000	4,000,000
Air mobility techniques	6,200,000	7,200,000	13,000,000
Heavy lift helicopter		15,000,000	3,500,000
Helicopter propulsion			3,000,000
Light observation helicopter	3,100,000	1,200,000	100,000
Bell UH-1 Iroquois testing	300,000	500,000	200,000
Boeing-Vertol CH-47A Chinook testing	10,200,000	10,200,000	5,300,000
Grumman OV-1B Mohawk testing	300,000	800,000	100,000
de Havilland Caribou 2		3,300,000	5,400,000
New surveillance aircraft	8,000,000	12,000,000	10,000,000
V/STOL Evaluation	12,000,000	12,000,000	10,000,000
Aircraft engines	2,000,000	3,700,000	1,500,000
Supporting developments	1,700,000	2,400,000	5,000,000
TOTAL	$55,800,000	$80,600,000	$82,700,000

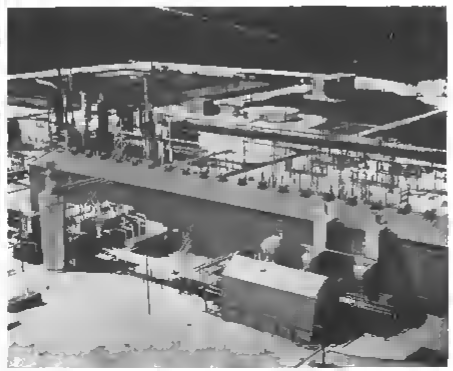


FRENCH ENTAC wire-guided anti-tank missile, above, is used by U.S. Army. Army's Redeye surface-to-air weapon, below, is being developed by General Dynamics/Pomona.

SOLID PROPELLANT PRODUCTION FACILITY—U.S. AIR FORCE PLANT #78. *Lummus' architect/engineering design for this propellant complex included auxiliary facilities for MINUTEMAN horizontal engine testing, propellant handling and storage considerations, and rocket-engine handling.*



LUNAR ENVIRONMENTAL RESEARCH FACILITY—U.S. ARMY CORPS OF ENGINEERS. *Lummus performed the conceptual engineering for this simulator which established the engineering feasibility to provide for vacuums up to 1×10^{-8} torr, temperatures as low as -423°F, and solar radiation twice the intensity of the noonday sun—up to 130 watts/sq. ft.*



WORLD'S LARGEST LIQUID HYDROGEN PRODUCTION FACILITY—U.S. AIR FORCE PLANT #74. *Lummus designed, engineered, and constructed the hydrogen production process phases of this plant to produce 99+% pure hydrogen, which is then liquefied through cryogenic processes.*

PROCESS ENGINEERING MODEL, U.S. NAVY PROPELLANT PLANT, NITROPLASTICIZER UNIT. *In addition to process design for nitroplasticizer unit, Lummus performed design functions for conversion of the unit from batch to continuous process; for a slurry-casting plant to produce intermediates for possible fuel application, and for attendant instrument-maintenance facilities.*

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one type in Fiscal 1965 for prototype development would provide for service by Fiscal 1969.

• **Utility transport helicopter.** Bell UH-1 Iroquois will be the Army's standard utility tactical transport helicopter for the next few years. Its primary mission is to provide tactical mobility for troops and supplies and for battlefield medical evacuation, but Bell currently is testing a modified Iroquois in an Army development program for an armed, high speed attack helicopter. The Fiscal 1964 buy of the Bell Iroquois will support the Army's decision to designate that helicopter as the replacement for de Havilland U-6A Beaver and Sikorsky UH-19D Chickasaw.

• **Heavy transport helicopter.** Army will buy the Boeing-Vertol CH-47A Chinook to transport troops, supplies and weapons. The Chinook is the only helicopter large enough to carry the Pershing missile inside. It can carry 33 passengers or three tons of cargo. Army has picked the Chinook as the replacement for the Boeing-Vertol CH-21C Shawnee, Sikorsky CH-34A Choctaw and Sikorsky CH-37A Mojave. But the Army plans to spend $3.3 million in Fiscal 1964 to evaluate the Chinook further to determine its role. There have been program slippages and cost overruns in the program.

• **Light fixed-wing transport.** Army has chosen the Beech U-8F Seminole for this role, succeeding the Beech U-8D.

• **STOL transport.** Army will buy additional de Havilland CV-2B Caribous in Fiscal 1964. Lt. Gen. Robert W. Colglazier Jr., Army deputy chief of staff for logistics, described the Caribou-Chinook team as providing the Army with a versatile battlefield transport capability. The Caribou replaces the de Havilland U-1A Otter. The turboprop-powered Caribou 2 with a fuselage enlarged enough to carry the Pershing missile is expected to become available for the Army in Fiscal 1965.

• **Aerial crane.** Army in Fiscal 1964 plans to spend $3.5 million of its research funds on tests and development of a heavy lift helicopter. But the Sikorsky S-64 Sky Crane will serve as the testbed and may be adopted for the role for the next few years. The S-64 can lift about 10 tons. Army by 1970 hopes to have a crane with a payload of 12-20 tons.

Army leaders are constantly seeking ways to make missiles more mobile, an endeavor which will be a significant portion of the service's research funds in the coming years. The Kennedy Administration's announced military strategy assigns a major role to tactical nuclear missiles if a land war should start in Europe. McNamara made this point clear in presenting the Defense Dept. Fiscal 1964 budget to Congress.

Army Aircraft on Order

Aircraft Type	Popular Name	Manufacturer
OV-1B combat surveillance	Mohawk	Grumman
CV-2B assault transport	Caribou	de Havilland
UH-1 utility helicopter	Iroquois	Bell
CH-47A transport helicopter	Chinook	Boeing-Vertol
OH-13 observation helicopter	Sioux	Bell
OH-23D observation helicopter	Raven	Hiller

Army Missiles on Order

Missile	Mission	Manufacturer
Mauler	Surface-to-Air	General Dynamics
Hawk	Surface-to-Air	Raytheon
Nike-Hercules	Surface-to-Air	Western Electric
Pershing	Surface-to-Surface	Martin
Honest John	Surface-to-Surface	Emerson Electric
Little John	Surface-to-Surface	Emerson Electric
Sergeant	Surface-to-Surface	Sperry
SS-11	Air-to-Surface	Nord
Entac (anti-tank)	Surface-to-Surface	Nord-l'Arsenal de Puteaux (DEFA)

"Although we are still a long way from achieving the non-nuclear capabilities we hope to create in Europe, we are much better off in this regard than we were two years ago. Today the North Atlantic Treaty Organization forces can deal with a much greater range of Soviet actions, without resorting to the use of nuclear weapons. Certainly they can deal with any major incursion or probe. But we must continue to do everything in our power to persuade our allies to meet their NATO force goals so that we will possess alternative capabilities for dealing with even larger Soviet attacks."

For the immediate future, the Army will buy new missiles to fill gaps in its armament, but at the same time will try to standardize more of the supporting equipment to gain mobility and simplicity. For example, Army for the first time will buy production models of the General Dynamics Mauler self-propelled air defense guided missile system in Fiscal 1964.

"Mauler will fill a void in the Army family of air defense weapon systems," Gen. Colglazier said. "This void is particularly apparent considering the threat to the forward elements of the field Army from very low-flying high-speed tactical attack aircraft and the various forms of battlefield ballistic missiles."

As for the standardization effort for missile supporting equipment, Gen. Colglazier cited the multi-system test equipment which will be used on several missiles—Mauler, Ling-Temco-Vought Lance (formerly Missile B) and the Aeronutronic Shillelagh. He said the test system will be able to perform about 85% of the tests required.

All told, the Army is asking for $580.7 million in new funds to buy missiles in Fiscal 1964. That figure includes $22.3 million for missile spare parts. Besides Mauler, other missiles to be bought in Fiscal 1964 from the procurement budget include the Raytheon Hawk and Western Electric Nike-Hercules air defense missiles. Artillery missiles include the helicopter-transportable Martin Pershing, improved versions of the Emerson Electric Honest John and Little John rockets and the Sperry Sergeant. Also on order is the French Entac anti-tank missile.

For missile research and development, Army is requesting $576.6 million in new funds for Fiscal 1964. "Our research and development objective for surface-to-surface missiles is to provide a family of missiles designed to support all combat elements of the field Army," Lt. Gen. Dwight E. Beach, Army chief of research and development, said recently. "Development of this family will provide commanders a minimum number of missile systems to replace five systems now operational. The new systems will be less complex than their present counterparts."

Gen. Beach said Lance development will be completed before 1970, and that it would replace the Honest John, the Martin Lacrosse and perhaps the Little John. Army, in Fiscal 1964, with about $14 million in research funds, will provide limited anti-tactical ballistic missile (ATBM) capabilities for Nike-Hercules and Hawk missiles. The General Dynamics Redeye shoulder-fired anti-aircraft missile will be continued in Fiscal 1964 though no new money was requested in the budget.

RED AIR FORCE BADGER is shown flying over a U. S Navy task force in the North Pacific Ocean with a McDonnell F4A Phantom 2 all weather fighter from the attack carrier Kitty Hawk as an escort (bottom center) Badgers based in Siberia flew over the Kitty Hawk while it was steaming off the Kurile Islands northwest of Japan in late January Note wide variety of radomes and antennas, indicating electronic ferret capability, and remotely controlled dorsal gun turret Also photographed was a Badger with wing pylon mounted fuel tanks

REFUELING PROBE for probe-and-drogue type refueling equipment is visible extending from nose of this Soviet Bear long range turboprop reconnaissance plane photographed over the Navy aircraft carrier Forrestal near the Azores on Feb 22. Note the new duck-billed radome that has replaced the plastic glass greenhouse nose and the series of camera ports along the Bear's belly. Bears operated from Soviet Arctic bases and reached Azores via Iceland where they were intercepted by USAF F-102 fighters

Soviets Press Technical Modernization

Soviet Union pressed hard during 1963 to continue technical modernization of its military forces at a fast pace New developments in space capability, a wide variety of missiles, anti-submarine warfare and aircraft took their places in the Soviet military spectrum during the year.

After trumpeting for five years over the "peaceful" nature of its space technology program, USSR during 1962 increased the bellicose emphasis on its military potential in a series of speeches by top-ranking Red Army marshals. This shift in the Soviet propaganda line on its space program occurred just after the successful double space flight and rendezvous exercise of Maj Nikolayev and Col Popovich in Vostoks 3 and 4

During the recent months since the Cuban crisis, the Soviet marshals have been rattling orbital weapons in a crescendo of speeches and now claim capability to launch rockets from orbiting satellites with precision Next Soviet manned space flight is expected to produce even more evidence of the essential military nature of its manned space flight program, which is headed by a Red Air Force lieutenant general and utilizes air force pilots exclusively as its cadre of cosmonauts

Considerable Progress

Soviets showed considerable progress in their missile program across its entire operational spectrum from deployment of air-to-air missiles to hardened ICBM sites and testing of an anti-ICBM system. The anti-ICBM defense system has been pitted against multiple incoming ICBM warheads in tests more advanced than the Nike Zeus vs Atlas contest conducted in the U. S. Pacific Missile Range. There are some indications of initial deployment of this SA-4 system around major target areas such as Moscow At the other end of the scale, the Soviets supplemented their standard SA-2 Guideline anti-aircraft missile—radar guided with an 80,000 ft. altitude capability and about 30 mi. slant range—with the SA-3 missile developed primarily to cope with low-flying aircraft, and similar in capability to the U. S. Army Hawk

The Soviets also took a major step forward in offensive missile capability with development of a solid-fueled Polaris type missile that can be launched underwater from a nuclear submarine. Initial underwater firing tests were successfully completed almost 18 months ago in the Arctic and the new missile was publicly paraded through Red Square in Moscow last November by Red Fleet personnel In turning to submarine-launched missiles and hardened ICBM sites, the Soviets are following the U. S. lead in an apparent effort to develop a relatively invulnerable second strike nuclear capability that would eventually lead to a nuclear stalemate between the U. S. and USSR

Although the Russians' international sabre-rattling emphasizes their offensive military capabilities in space and with ICBMs, modernization and expansion of the Red Air Force continues through development of new types of aircraft ranging from supersonic bombers to helicopters, and modification of existing aircraft with new armament, electronics and range capabilities to enable them to maintain an active role in the massive fleet.

Latest demonstration of the modernization of venerable Red Air Force aircraft was provided a few weeks ago when new versions of the Bear Tu-95 turboprop bomber appeared over U. S. Navy aircraft carriers in the Atlantic off the Azores. The Bear has been in the Soviet bomber fleet since 1955 but the long-range reconnaissance versions photographed by Navy fighters over the USS Forrestal and USS Enterprise had been modernized with aerial refueling equipment, new long-range search radar, considerable electronic intelligence ferret equipment and multiple camera installations

Cruise Missile

These forays by the Russian-based Bears into the Atlantic were the longest known missions these aircraft have assayed, although earlier reconnaissance missions photographed the USAF North African bomber bases. The Bears, which originally had plastic glass bombardier noses in addition to radar bombing equipment and relied on free fall bomb delivery, have also been modified with an air-to-surface supersonic cruise missile that is known as the Kangaroo, with a range of over 500 mi.

Similarly, the Soviets have modified the aging Badger Tu-16 twin-jet bomber, which is about the same design vintage as the Bear, to perform a variety of modern offensive and reconnaissance roles To extend its offensive capability the Badger has been equipped with two types of air-to-surface missiles One of these missiles used on Badgers assigned to the Red Navy looks like a scaled down MiG-17, has a radar guidance system and is apparently designed primarily as an anti-shipping weapon from ranges of less than 150 mi. Called the Kennel, this missile is carried under each wing of the Badgers, which have been modified to carry special search and guidance radar in the nose

The other Badger-mounted missile called Kipper, appears similar to the USAF Hound Dog, utilizes turbojet or ramjet propulsion and radar guidance system and has a range of several hundred miles A single Kipper is mounted under the Badger fuselage centerline Other Badgers have been equipped with external fuel tanks for extended range

SOLID RADAR NOSE has replaced the bombardier's plastic glass greenhouse on this Soviet Badger. Note stub antenna between astrodome and gun turret and radar-controlled tail turret.

and a wide variety of electronic intelligence ferret equipment.

Aside from the modernization of the Bear and Badger fleets—about 200 Bears and 1,700 Badgers—the Soviets appear to be concentrating on developing new types of tactical and defensive aircraft. The new Blinder, first seen at Tushino in 1961, is probably aimed at a Badger replacement, but even with aerial refueling capability and its air-to-surface Kitchen missile it probably could not be classed as a strategic bomber. Indications are it is aimed at strike-reconnaissance missions in the medium-range category.

Stroeg ASW Effort

Soviets are devoting considerable effort to improving their airborne anti-submarine warfare capabilities particularly to defend against Polaris-carrying nuclear submarines. The Beriev series of flying boats—the turboprop-powered Be-8 Mail and the turbojet-powered Be-10 Mallow—appeared to be designed only for Baltic and Black Sea operations with relatively limited range for ASW work. Development of an ultra-long range ASW aircraft is under way, but there is little information on its configuration or progress available in the West. It is based on prototype development of the Bounder, and is reported to utilize nuclear powerplants. Air Marshal Konstantin Vershinin, chief of the Red Air Force, made several references in public speeches last year to the development of nuclear aircraft engines, a subject hitherto only discussed at the engineering level.

Soviets embarked on their biggest foreign military adventure since Korea in the summer of 1962 when they poured a formidable force of Russian troops and weapons into Cuba to secure the island as a bastion of Russian imperialism in the Western Hemisphere, and a ballistic missile base aimed at outflanking U.S. radar detection systems and checkmating Strategic Air Command's 15 min. alert capability.

Because of the reluctance by the Kennedy Administration to admit the scope and character of the Soviet military build-up in Cuba as it occurred, the full nature of this effort has only recently become apparent. Considering all of the Soviet shipping and logistics involved, the Cuban military effort must have cost the USSR well over a billion dollars.

Decision to mount the Cuban military effort must have been made in the Kremlin in the late spring or early summer of 1962. Beginning in late July and early August, Soviet shipping volume to Cuba suddenly increased and stringent security measures were taken by the Russians to bar native Cubans from the port areas where these ships were being unloaded. All personnel involved in the unloading of these ships were Russian. This represented the beginning of an influx of Russian troops and technicians into Cuba that reached a maximum of 22,000 by October. The Soviet ships carried their deck loads in crates, and most of the critical military equipment including missiles, tanks, etc., were carried in the holds, where the only clue to their contents was unusually large hatches up to 80 ft. long.

U-2 Spots SA-2 Site

During this period, a regular weekly schedule of high-altitude photo-reconnaissance was flown over Cuba by Lockheed U-2 aircraft operated by the U.S. Central Intelligence Agency. On Aug. 29, a U-2 mission photographed the establishment of eight Russian SA-2 Guideline anti-aircraft missile sites and one coastal defense missile site. These Russian-manned sites had all attained an initial degree of operational readiness before they were discovered, although in subsequent weeks they were improved considerably with heavy revetments, access roads, protected missile storage areas and protective installations for personnel in case of air attack. This swift transition from dockside unloading to initial operational capability in the field, without U.S. photo-recon detection, was characteristic of all types of Soviet missiles deployed in Cuba.

Even high altitude U-2 flight from Aug. 29 through Oct. 7 revealed new SA-2 installations until a total of 24 sites were tallied, each housing six missile launchers equipped with two missiles. These 24 SA-2 sites, offering a slant range of 30 mi. and an altitude coverage up to 80,000 ft., gave complete defensive cover to the entire island of Cuba and made it impossible for U-2s to photograph their assigned targets without coming within the Guideline missile range. One U-2 was hit and destroyed by a Guideline missile on Oct. 23 near Banes, but this was the only time during the Cuban crisis that anti-aircraft defenses were used against U.S. photo planes.

Radar Defenses Grow

By the time the SA-2 sites and other defenses were completed, the Soviets had more than 200 modern radar sets operating in Cuba. They also enlarged their coastal defense missile deployment to five sites equipped with a total of 150 rail-launched stub-wing cruise missiles with a range of 40 mi. A 5,000-man armored task force was shipped to Cuba equipped with T-54 tanks, self-propelled assault guns, armored recon cars, mobile anti-tank missile launchers, Frog 25-mi. range solid-fueled rockets and armored personnel carriers. In addition, 40 MiG-21 Fishbed Mach 1.5 interceptors equipped with infrared homing Atoll air-to-air missiles were introduced to Cuba, completing an integrated air defense system for the island. The MiG-21s were piloted and serviced by Red Air Force personnel.

By mid-October, Cuba had changed from a relatively soft-shelled target for external invasion or internal revolt to a hard rock bastion of Soviet strength bristling with modern weapons. In the meantime Soviet ballistic missiles and Il-28 Beagle bombers began arriving at Cuban ports in strict secrecy. First Sandal missile reached Cuba in mid-September, but it was not until Oct. 14 that the first USAF SAC U-2 was able to get the first picture of a Sandal squadron. This picture was taken early on the morning of Oct. 14, shortly after SAC took over the Cuban photo mission from CIA, and showed a Sandal squadron in field deployment in the San Cristobal area with initial firing capability already achieved. Photos later in the same day caught several other Sandal squadrons deploying in the same general area.

U-2 high altitude photography between Oct. 14 and Oct. 23, when President Kennedy ordered low-level photo sorties by Navy F8E and USAF RF-101 fighters, revealed five more Sandal squadrons deployed in the San Cristobal and Sagua la Grande areas. On Oct. 17, construction was photographed in initial stages at two IRBM missile sites, at Guanajay and the first of another two planned IRBM complexes at Remedios.

The Sandal missile squadrons were regular Red Army rocket troops moved from permanent stations along the western frontier of European Russia. They exhibited remarkable skill in their quick field deployment that attained initial operational firing capability in less than 48 hr. from their debarche from the Cuban docks. With this capability achieved, they moved quickly to improve their sites into semi-permanent installations, pouring concrete firing pads, building earthern blast shields for fuel and oxidizer trucks, constructing pre-fab concrete nuclear warhead storage facilities and erecting missile check-out tents on concrete foundations capable of holding the missile erector transporters, and eventually shifting from their field tents to wooden barracks.

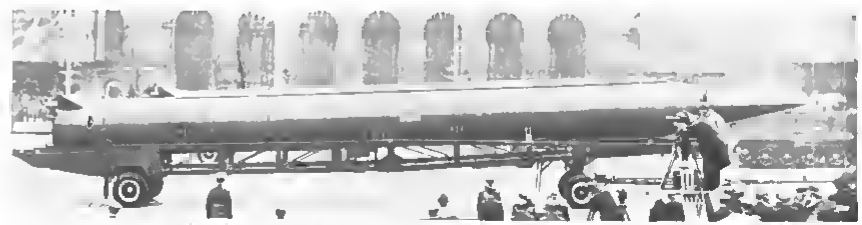
The Sandal squadrons achieved full operational readiness in their four San Cristobal sites and two at Sagua la Grande on Oct. 27, the day that Chairman Nikita Khrushchev informed President Kennedy the missiles would be removed. In the meantime, the deployment of Soviet military forces into Cuba stopped on Oct. 23, when some 15 Russian ships with military loads reversed course in the face of the U.S. naval blockade and headed for home.

These ships included the Poltava, which had first been spotted by U.S. planes on Sept. 15 putting into Mariel with what later was determined to be the initial load of Sandal missiles concealed in her holds. It is believed that among the 15 Soviet ships headed for Cuba on Oct. 23 were at least five including the Poltava, carrying the longer range IRBM missiles destined for Remedios and Guanajay. Only fueling trailers for the IRBMs—with much larger capacity than those deployed with Sandals—were actually spotted in Cuba. Only two Soviet ships have arrived in Cuba since Oct. 23 with military cargo and troops. Their cargo was mostly six-by-six trucks and large flatbed trailers.

Removal Begins

On Oct. 28, the first Sandal squadrons were observed removing their equipment from the firing pads and getting ready to move out of their sites back to the Cuban ports. By Nov. 1 the jackhammers were breaking up the heavy concrete IRBM launch pads, pulling up guidance and power cable conduits and razing launch control buildings. By Nov. 9 all 42 Sandals that had been deployed in Cuba, plus their supporting equipment and troops, had been shipped out of the island in Soviet bottoms and the missile crisis was over.

The crated Il-28 Beagle bombers arrived in Cuba in mid-September and were deployed at San Julian and Holguin airfields. Since four of the first seven Il-28s assembled at San Julian were the Mascot trainer versions, it was apparent that the Soviet pilots intended to check out Cuban crews on the remaining 38 bomber versions. By mid-November, the Il-28s were being re-crated for transport back to Cuban ports and the last of the bombers left for the USSR on Dec. 7, 1962. With the Sandals and Beagles, about 5,000 Soviet troops and technicians left Cuba, leaving some 17,000, including the Guideline operators, MiG-21 pilots and the armored task force. Whether or not these units leave Cuba during the first half of 1963 will determine how the Soviet military venture in Cuba will finally end.



SOVIET SANDAL MRBM missile is shown in Moscow's Red Square during armed forces day parade last November. This is same type missile deployed to Cuba last September, precipitating U.S. naval blockade. Missile is liquid fueled and has estimated 700-mi. range.

Severe Internal Crisis Threatens NATO

By Cecil Brownlow

Paris—North Atlantic Treaty Organization, wracked by a number of long-dormant problems that have now flared into the open, is facing its most severe internal crisis since its organization in 1949—one that is creating serious concern over its future beyond 1969.

For the first time since its inception, the basic structure of NATO itself is being subjected to a series of critical reappraisals that conceivably could reduce the organization to a bureaucratic hulk, empty and ready for abandonment when the present treaty among the 15 Western nations expires in six years.

Whatever the final ramifications, these reappraisals will have a substantial effect on the future roles of the U.S. and American aerospace firms within the framework of Western Europe. Present issues include:

- **Form of NATO itself.** Should it remain primarily a military organization, be expanded to become a political economic force, contracted to become something of a technological clearing house—or simply abandoned?
- **Cooperation within** the alliance, an achievement that apparently is becoming increasingly difficult to attain even on matters of weapon system standardization. NATO working officials, for example, have been bitterly disappointed by the apparent breakdown along nationalist lines of the organization's attempt to standardize on development and production of a V/STOL close-support fighter and a supporting V/STOL medium-range transport.
- **Its role as a nuclear power,** the position and influence of the U.S. in any such multi-lateral force, and France's attitude toward it.
- **Role of the U.S.** within a prospering Western Europe where France is seeking dominance. The French and others also are becoming concerned over whether the U.S. actually would meet its commitments and launch its strategic nuclear force to protect Western Europe against a Soviet attack, when this would mean the destruction of much of the U.S. and its resources.

Basic reason behind much of the current unrest within NATO can be explained by an overly simple formula.

France wants the U.S. and its British ally, including a major portion of their industrial influence, out of Western Europe. Once this is accomplished, President Charles de Gaulle foresees Europe becoming a powerful "third force" roughly aligned with America but independent from any form of control except that emanating from Paris.

France's drive under President Charles de Gaulle to attain these goals has been heightened by a persistent U.S. refusal to aid the French in development of an independent nuclear force, including a direct prohibition order to American firms and by what France regards as its resultant second-class partnership within the alliance.

The December U.S. agreement to provide Polaris missile systems to the United Kingdom as part of a national force and a subsequent similar offer to France was regarded by de Gaulle as essentially an empty gesture. It provided sufficient additional rancor to confirm his decision to veto Great Britain's application to join the European Common Market.

Britain, it is argued, can build a nuclear warhead to fit the Polaris within an acceptable time limit. France cannot, and its officials view the offer as "unequal and unfair," a covert move designed to entice France into abandoning its own atomic force.

This means that in France's opinion, NATO theoretically should be largely abandoned, ignored or sent through a radical transformation, because, as now constituted, its most dominant voice is that of the U.S.

It does not necessarily mean, however, that France will simply walk away from the organization, at least not before expiration of the 1969 treaty date.

Officials working closely with the problem believe France will continue to cooperate and work with NATO in areas which coincide with its own national interests, particularly in the economic and technical fields.

Despite the open rejection of the Polaris offer and the rebuff of Britain, French officials within NATO are continuing to cooperate in these two spheres through NATO's various committees and standing groups.

On the technological side—because it is in its own interest to do so—France is expected to maintain its active collaboration in a number of multination production efforts. These include the already operating consortium for the Raytheon Hawk anti-aircraft missile and the anticipated NATO projects for advanced systems, such as the General Dynamics/Pomona Redeye infantry surface-to-air defense missile.

Thus far, France also has continued its active participation in a relatively new research, development and production group formed within NATO. This group has the task of finding areas where new developments are needed in which a multi-lateral approach from the beginning of the concept might produce an agreement on a single piece of hardware for the participating nations.

The group, as such, was formed after the BMR-3 competition for a close-support V/STOL fighter appeared doomed by France's insistence that it planned to buy and build the Dassault Mirage 3V whether the aircraft won the NATO award or not, and after the BMR-4 attempt at standardizing on a V/STOL transport collapsed when the U.S. withdrew any promise of financial support. An effort currently is being made to revive BMR-3 (AW Mar. 4, p. 31), but its chances of success admittedly are doubtful.

"We sat down" one official relates "and tried to figure out just why these programs died, and we decided that the only way to tackle a majority of these [common production] programs was to get in at the start before any one had a project going. This way we might avoid some of the nationalism."

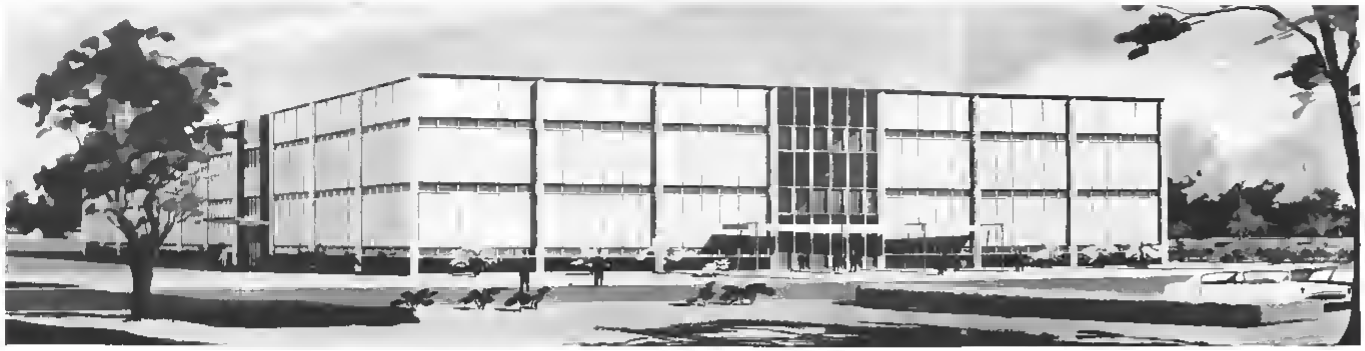
As conceived, the U.S., for example, would cooperate in such a project when it could gain from European technology. The same would be true for the European nations involved. Specific areas of development need and capability would be decided upon, competitions held, and subsequently, a contract awarded for research, development and, eventually, production on a cooperative basis.

Here, the U.S. may find itself on occasion as the non-cooperative member. Mutual weapons development funds, which played a large part in shoring up the European industry after World War 2 to a point where it can effectively compete with the U.S. in a variety of technologies, are now ending. American funding for such cooperative projects probably would have to come from the military budgets of one or more of the three military services.

Persuading any one of the services to part with a share of its budget for such purposes could be difficult to say the least, officials here concede.

There is no doubt, however, that the composition and, to a degree, the missions of NATO will undergo a change. Similarly, there is little doubt that U.S. aerospace firms will find it increasingly difficult to sell in Europe, particularly France, except in areas where there is an urgent need and a minimal European capability.

Even here, the U.S. in combatting



FACILITIES

Latest step in Grumman's long-range aerospace programming is construction of a new $5 million Aerospace Engineering Center, shown here in an architect's drawing. Along with the recently completed Electronics Systems Center and in-progress Research Center, this new complex of aerospace facilities will give Grumman the physical capabilities and resources to undertake major space system assignments.

EXPERIENCE

In the early 1950's, Grumman instituted a comprehensive, long-range program of space studies. Significant areas were hypersonics, reentry, capsule retrieval, orbital transfer and lunar vehicles. Major accomplishment to date is acquisition of the OAO (Orbiting Astronomical Observatory) contract for Goddard Space Flight Center (NASA), the Echo II canister assembly, and the Lunar Excursion Module (LEM) in connection with Project Apollo. More recent study contracts include the performance study for Lunar Logistics Systems and a new contract study in Lunar Astrodynamics. Against the background of 33 years' experience in solving the man-machine equation in aircraft and weapons systems, Grumman now offers a fully integrated space capability.

AND ESPECIALLY

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the "gold flow" problem from the U S is becoming increasingly severe in its scrutiny of requests from firms for permission to grant licensed production rights to a European counterpart. The Europeans want to buy needed technology. The U S would prefer to sell off-the-shelf wherever possible in order to increase the dollar flow to the West.

Within this over-all framework, particularly when related to various national political interests, it is still unclear as to just how NATO will emerge.

The U S—and West Germany to a great extent—still regards NATO primarily as a military organ, a "shield" against Communist aggression and, in an effort to rebuild the organization's vitality, it is belatedly pushing its proposals for the establishment of a multilateral nuclear missile force with American-supplied warheads that would remain under U S control.

At the same time, it is calling upon other NATO nations to buy American equipment whenever possible to help offset the cost of the support in men and material the U S is channeling into NATO in an effort to maintain it as an effective force.

French Ambitions

Despite France's ambitions, the U S intends to remain in Europe. First, to protect itself and second, to avoid a further proliferation of nuclear weapons by offering the individual countries a sufficient role in a multi-lateral force.

It also hopes, despite the present tensions among some of the European NATO members, that a common effort in such a project can restore a measure of cohesion in the political thinking and military effort of the alliance.

In a substantially different approach to NATO's future, a number of top British officials are beginning to regard NATO as a potential backdoor through which Britain might gain entry into the political and economic structure of Western Europe despite France's determination to the contrary. Such a move undoubtedly would create new structures within the already strained alliance.

French leaders, aside from generally wanting to diminish U S influence in Western Europe, tend to regard military alliances as essentially worthless in a nuclear age. The U S, they say, would never use its nuclear power against the Soviet Union now that the latter has attained relative parity in this area unless its own territory were under or threatened by, a nuclear attack.

This means, they contend, that NATO as a military force has seen its day. Each country must depend upon its own resources for survival.

Because of this—and because of President de Gaulle's belief that entry into the "nuclear club" will restore his country to its former glory—France is remaining diligently aloof from all pressures to participate in any multi-lateral combine, relying instead upon its own force now under development.

Main purpose of the country's Mirage 4s, Mirage 3Vs and 3Es and Dassault Etendard 4Ms, beyond matters of prestige, is to place the price the Soviets would have to pay for conquest beyond what it is willing to pay—an estimated five cities on the part of Mirage 4s plus any damage the follow-up tactical aircraft would be capable of inflicting.

U.S. Urgings Ignored

Under this philosophy, France sees little need for a buildup of its conventional forces and probably will continue to ignore U S urgings in this direction.

France now has two NATO committed divisions in West Germany as opposed to the four it is scheduled to maintain under present NATO force requirements. Another two are in France re-equipping after several years in Algeria. They are not expected to be placed under direct NATO control anytime within the near future.

Some French officials also tend to regard U S proposals for a sea-based multi-lateral force, coupled with the planned withdrawal of Jupiter missiles from Turkey and Italy and President Kennedy's emphasis upon a buildup of conventional warfare capability as evidence of a "nuclear disengagement" from Europe.

Such a "disengagement" is flatly denied by responsible U S officials here on all counts. The Jupiter withdrawal, they maintain, is being carried out primarily because the weapons themselves are obsolescent and can be replaced more effectively by three American-manned Polaris submarines that will be roving the Mediterranean by Apr. 1.

Increasing the conventional warfare capability of U S forces in Western Europe, including modification of the aircraft in its two Republic F-105 fighter-bomber wings stationed there to permit them to carry high-explosive bombs, is designed primarily to give the President an opportunity to assess Soviet intentions without having to resort immediately to nuclear retaliation.

Unanswered Questions

The composition of the multi-lateral nuclear force itself, the means by which it will be controlled and the scope of participation by countries other than the U S are matters still largely to be decided.

It appears, however, that initial plans to install the Polaris aboard submarines manned by multi-nation crews is being abandoned in favor of placing the 3,000-mi.-range A3 version of the missile aboard surface vessels, primarily cargo ships.

Switch to the more vulnerable surface system apparently was decided upon largely as a matter of expediency in order to have the missiles in place at the earliest possible date. Moreover, it would be cheaper in over-all dollar cost—an important factor since the other participating nations will be called upon to share in the burden of training crews and the conversion program for the vessels themselves would be accomplished in European shipyards.

One vessel already is available. Shortly after Italy indicated its willingness to participate in the multi-lateral force, its government announced that an Italian cruiser, the Giuseppe Garibaldi, had launched dummy Polaris configurations from tubes fitted to its deck during test trials last year.

Other nations that have indicated a willingness to participate in the project include Great Britain, which also will make its V-bomber nuclear strike force available to NATO under recent agreements with the U S., West Germany, Belgium, Greece, Turkey and The Netherlands.

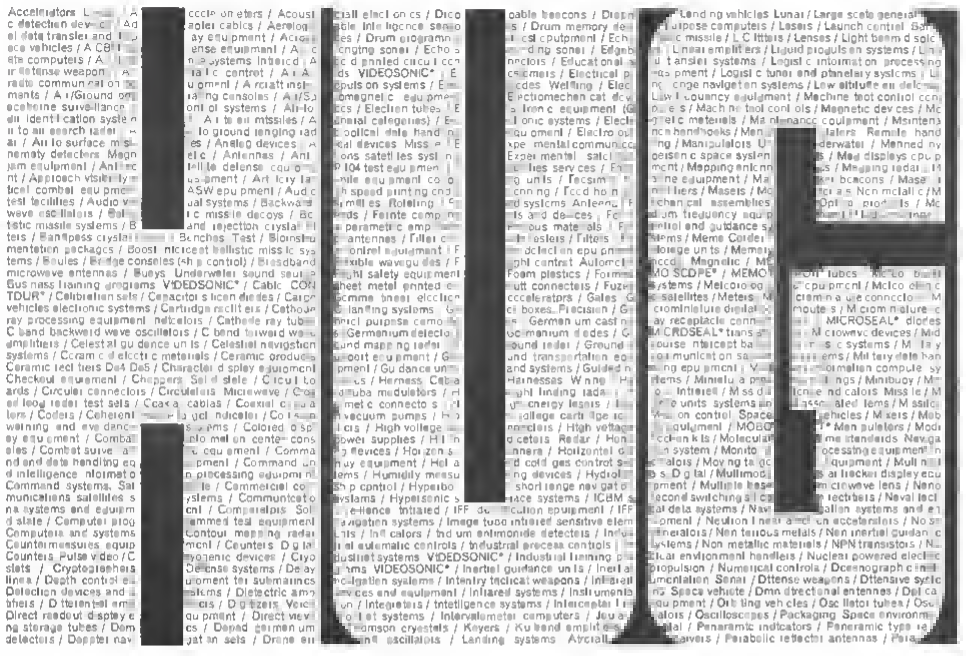
France will remain outside, but Undersecretary of State George Ball has told the other countries concerned that the U S is "prepared to move ahead vigorously in cooperation with the NATO nations whether the French government decides to accept our offer or not."

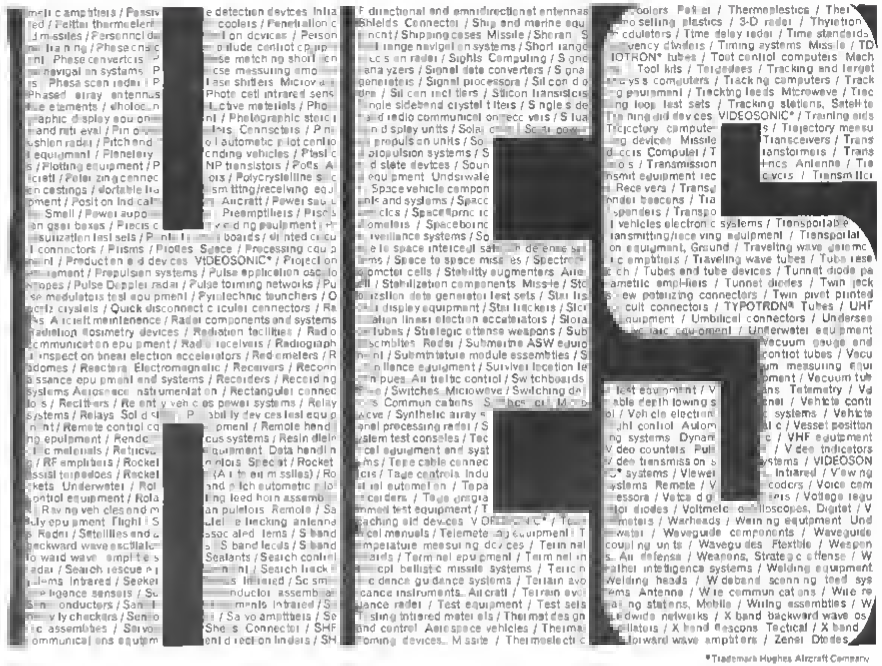
Weapons Control

The matter of weapons control can be difficult, particularly since congressional sources have made it known that they have no intention of relaxing the restrictive U S legislation concerning the use and placement of American-developed nuclear warheads. This means, essentially, that the President of the U S retains the only authority to issue a firing order, since the warheads for the multi-lateral Polaris systems will be supplied directly from America.

One alternative under discussion would provide for a NATO consultive body that would share in the force's targeting assignments and help carry the burden of its responsibilities short of assuming actual control of the weapon.

U S also is moving slowly in this area for yet another reason. It is impossible to foresee just what the composition of several Western governments, including Britain, will be within a year's time. West German Chancellor Konrad Adenauer is scheduled to step down this fall, President de Gaulle's tenure is unknown, and British Prime Minister Harold Macmillan faces an election next year against Labor leader Harold Wilson, whose record to date has not indicated an overwhelming fondness for Britain's present nuclear commitments.





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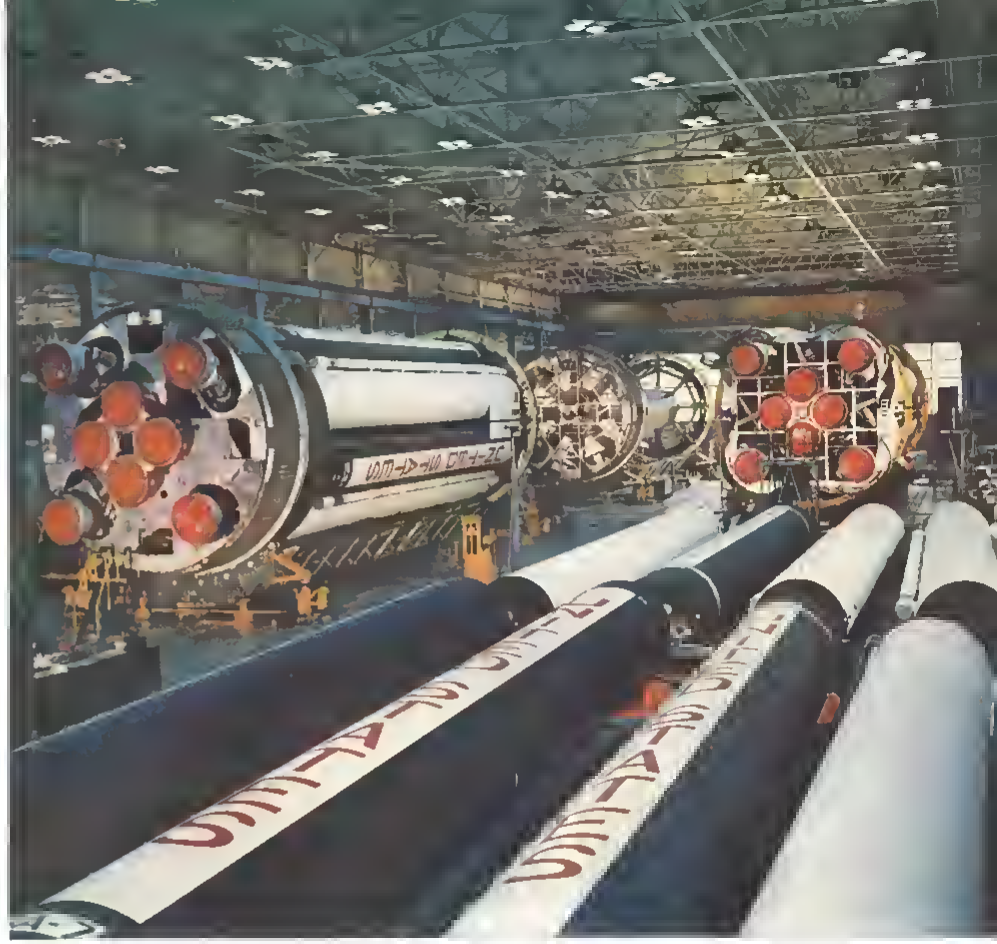


Assembly of initial series of Saturn 1 booster first stages is carried out in the main assembly building at the Marshall Space Flight Center. Tanks for SA-7 in foreground are ready for mating in jig in center background. Completed SA-6 is at left; SA-4, now on launch pad at Cape Canaveral, is right.

Space Technology

U.S. Space Effort Turns to Gemini, Apollo

By Edward H. Kolcum

Washington—Vast U.S. investment in manned space flight during the next 12 months will be a down payment on the future and will not buy large numbers of flights this year.

Maj. Gordon Cooper's attempt to wring the maximum performance from the Mercury capsule in late spring is the only manned flight scheduled this year. If successful, the MA-9 will conclude the Mercury program and set the stage for Gemini in 1964 and Apollo a year later.

Because the major U.S. effort must now be measured as a promissory note, its status can best be analyzed in terms of dollars and what the dollars are to buy. National Aeronautics and Space Administration is asking Congress for $3.2 billion to develop manned space flight systems in Fiscal 1964, and for an additional $564.5 million to build facilities to support the new developments. The agency will commit 13,389 people—nearly half its total staff—directly to developing manned flight systems. The dollar and personnel resources sought are in the following major areas:

- **Spacecraft:** $1.6 billion, 4,844 personnel.
- **Launch vehicles:** $1.3 billion, 7,710 personnel.
- **Integration and checkout:** $157 million, 154 personnel.
- **Systems engineering:** $47.5 million, 440 personnel.
- **Aerospace medicine:** $21.5 million, 241 personnel.

Level of effort will be at least as great for the next few years, and it could increase substantially if the nation decides to embark on an advanced project such as a space station or permanent lunar base while still funding Apollo.

The Apollo spacecraft system is the most ambitious program among the 51 separate items in NASA's program inventory. It is the first line item in the agency's history for which more than a billion dollars is being requested in a single year.

Design parameters and the lunar orbit rendezvous mission concept were defined for the Apollo system last July, but only after an fighting between NASA and several members of the President's Science Advisory Committee, who felt that lunar orbit rendezvous would be too complex an operation.

The space agency won the fight by arguing that lunar orbit rendezvous will save time and money. But Dr. Jerome B. Wiesner, President Kennedy's science adviser who led the opposition, has succeeded in reopening the case to the extent that Congress will conduct hearings to bring into the open the reasoning behind the decision.

The Apollo hardware program is only 15 months old, but NASA is requiring a fast-pace[illegible]ction rate for boiler

MANNED space flight continues to command the largest share of NASA's budget request

MOCKUPS OF GEMINI SPACECRAFT and Agena rendezvous adapter section are assembled by McDonnell technicians.

NASA Vehicle Payload Assignments

Vehicle designation		Payload
Saturn 1	4	Booster test
	5	Booster/S-4 stage test
	6, 7	Apollo boilerplate
	8, 9	Meteoroid satellite
	10	Apollo production command, service module
	11*	Manned Apollo ballistic
	12, 13, 14	Manned Apollo orbital
Saturn 1B	201	Vehicle test/Apollo boilerplate
	202	Apollo production command, service modules
Titan 2	1	Gemini unmanned ballistic
	2 through 12	Manned Gemini orbital
Atlas Agena	8 through 10	Rangers 7 through 15
	13 through 18	
	12, 21	EGO 1, 2
	19, 20	Mariner MC-1, 2 (Mars fly-by)
	22	OAO-1
	301 through 308	Gemini target (Agena D)
Thor Agena	2	Echo 2
	3, 5, 9	Nimbus tests (A-1, 2, 3)
	4, 7, 10	POGO-1, 2, 3
	6, 8, 11, 12	Operational Nimbus (0-1, 2, 3, 4)
Centaur	2, 3, 6, 10, 13	Vehicle tests
	4, 5	Surveyor dynamic models
	7, 8, 9, 10	Surveyor spacecraft tests
	12, 14, 15	Surveyor lunar lander/orbiter
Thor Delta	17, 23	S-6, S-6A (atmospheric structures)
	18, 22, 30	Tiros 7, 8, 9
	19, 25	Syncom 2, 3
	20, 24	Relay 2, 3
	21, 27	Telstar 2, 3
	26, 32	OSO 2, 3
	28, 29, 31	Interplanetary monitor satellites (IMS-A, B, C)
Scout	12, 15	Re-entry tests (ballistic)
	13	S-48 (topside ionosphere sounder)
	14, 17	S-66 (polar ionospheric beacon)
	16, 18	SERT 1-A, 1-B (ballistic)
	19, 20	S-52, S-52A (British payloads)
	21, 22	S-55C, S-55D (micrometeoroid detectors)
Little Joe 2	1	Vehicle development
	2, 3	Apollo boilerplate (pad abort test)
	4	Apollo boilerplate (max. dynamic pressure escape)
Atlas-X-259	1, 2	Fire 1, 2 (hyperbolic velocity re-entry)

* Three-digit numbers are assigned to operational Saturns and to the Atlas Agena D vehicles in the Gemini program.

plate and man-qualified spacecraft. North American Aviation's Space and Information Systems Division was awarded the prime contract in December, 1961. The company will deliver 10 test command service modules before June, and another 14 spacecraft before July 1, 1964. Two being delivered next year will be the first man-rated spacecraft and will be flown on two-week earth orbital missions in 1965.

Production rate of four complete Apollo flight systems each year has been established for 1965 and succeeding years.

Apollo spacecraft development program is divided into six major categories. Following chart shows the funding trends in each, with money figures in thousands:

Component	Fiscal 1964	Fiscal 1963
Command/service modules	$661,000	$269,000
Lunar excursion module	230,000	32,000
Guidance, navigation	131,000	45,000
Instrumentation, science experiments	9,500	4,000
Subtotal, spacecraft	$1,031,500	$350,000
Saturn 1	$75,000	$55,200
Saturn 8	55,000	
Little Joe 2	5,000	4,500
Subtotal, launch vehicles	$135,000	$59,700
Supporting development	$25,000	$5,000
Salaries in-house operation	$55,700	$26,900
Operations	$16,000	$1,000
Facilities		$20,000
Total, Apollo spacecraft	$1,263,200	$462,600

This summary includes incremental funding to purchase the actual flight vehicles, and to plan flight trajectories. Development of the launch vehicles is included in the launch vehicle category, discussed subsequently.

Contract with North American specifies that the company will design, develop and manufacture Apollo command and service modules, construct the adapter section between the spacecraft and launch vehicle, integrate systems and equipment, assemble and test the complete spacecraft and prepare it for flight. North American also is to integrate the lunar excursion module (LEM) being built by Grumman Aircraft Engineering Corp. into the spacecraft package.

The three-man command module weighs about 10,000 lb. and has an internal volume of 300 cu. ft. Offset center of gravity will give it a lift/drag ratio of 0.5, permitting fairly extensive atmospheric maneuvering after re-entry. Landing footprint will be 5,000 mi. long and 200 mi. on either side of a centerline.

The service module houses the Aerojet midcourse correction and maneuvering engine, an attitude control system, fuel cells and electric power supply, radars and radiators. The engine, designated AJ10-137, will provide midcourse velocity corrections, inject and eject the Apollo spacecraft into and out of lunar orbit, and correct the lunar orbit. It also will have an emergency requirement to rescue a disabled excursion module. Developing 22,000 lb. thrust, the rocket engine will be fueled by hypergolic propellants and will be capable of multiple restarts—possibly as many as 50.

The lunar excursion module has been under development by Grumman since last December, and the goal is to define the final configuration by June. This two-man vehicle, sometimes called a lunar bug, is an entirely self-contained spacecraft, with its own environmental, life support and power systems. It may be modified into a truck by replacing the liftoff engine with a cargo platform. By removing all manned requirements, it could soft-land up to 6,000 lb. of cargo to support the first manned Apollo flight.

General Dynamics/Convair Little Joe 2 will test all three modules at the White Sands Missile Range beginning next August. Little Joe 2 is a cluster of seven Aerojet Algol solid propellant motors which can be ignited in sequence to provide staging, or simultaneously to loft a heavy payload.

Identical guidance and navigation system equipment will be used where possible in command and excursion modules to increase reliability of the systems. Under development by the Massachusetts Institute of Technology, the guidance system consists of three principal components: an inertial unit, being built by the AC Spark Plug Division of General Motors; optical subsystem, by the Kollsman Instrument Corp.; and guidance computer, by Raytheon Corp.

Research instrumentation for the first two manned earth orbital flights is being developed with Fiscal 1963 funds. Ser-

ASSEMBLY OF APOLLO CAPSULE (top, foreground) and service module (background) is under way at North American's Space and Information Systems plant. Static firing of Rocketdyne's F-1 1.5 million lb. thrust engine is carried out (below) at Edwards AFB.

entific instruments for the succeeding eight Apollo flights will be bought with Fiscal 1964 money. Included in this program are cameras, television systems, seismometers and magnetometers.

First sizable funding increment for operational launch vehicles is reflected in the Fiscal 1964 budget, because the first vehicles for manned launches will be delivered during this period. NASA will buy six Saturn I vehicles capable of orbiting the command module only, and an unspecified number of Saturn B launchers, which can place the entire Apollo spacecraft in earth orbit. This is the first key milestone of the three-part Apollo flight program. The others are circumlunar and lunar orbital flights, followed by the manned landing mission.

Continued development of manned space flight capability prior to Apollo will be the role of the Gemini program. Design of the two-man Gemini spacecraft is essentially completed, and the first man-rated system will be delivered late this year by McDonnell Aircraft Corp. which also built the Mercury spacecraft. Gemini is designed fundamentally on Mercury technology.

Build-up of the Gemini contractor base did not take place as quickly as it could have during the past year because the over-all system cost has grown higher than anticipated. However, production will reach its peak during the next 12 months, with this funding level:

• **Spacecraft,** $196.2 million. Only one unmanned launch is planned in this program, a ballistic lob, with the target date still scheduled for December. NASA is scheduling manned flights in the early spring of 1964. The contract calls for delivery of 12 spacecraft for 15 missions; three capsules will be refurbished for second flights. Five spacecraft will be delivered in Fiscal 1964. Contract probably will be extended for additional Air Force capsules as the result of an agreement which makes USAF an active participant in the Gemini program.

• **Launch vehicles,** consisting of a family of three: Martin Titan 2, $46.9 million, Lockheed Agena D, $32 million, and General Dynamics/Astronautics Atlas D, $15.9 million. Titan 2 is the Gemini launch vehicle, and Atlas will launch an Agena target stage for the Gemini rendezvous mission. Standard military Titan 2s will be modified for the Gemini mission to use radio instead of inertial guidance, and with addition of a malfunction detection system, redundant control system and added checkout and test leads. Five Titan 2s in the total order of 15 will be delivered in Fiscal 1964. During the coming year, USAF will qualify the specialized Gemini components in Titan 2 missile tests. General Dynamics will

MANUFACTURE of Saturn components has begun by both Chrysler Corp. and Boeing Co. at Michoud, La. Tanks for the Chrysler Saturn 1 first stage are shown in storage area (top) and thrust structure for the S1-8 first stage is being moved from Station 1 to a rotary inspection table (center). Boeing employes are lifting y-ring for Saturn 5 from boring mill for mounting on foundation for X-ray and other tests.

deliver three Atlas vehicles for the Gemini program next year, and Lockheed a single Agena D stage. Rendezvous mission for Gemini comes in 1964 or 1965, about a year after the long-duration flights.

• **Operations**, funding at $14.6 million will pay flight control teams at network sites, and provide weather surveys for missions. Also in this category is money for continuing studies of rendezvous, docking and maneuvering techniques.

NASA will continue work on a suit for extravehicular experiments, and for bio-instrumentation development. The agency plans to spend about $700,000 for these developments and to reimburse USAF for testing ejection seats and for support in test of the Gemini paraglider and parachutes.

First U. S. manned space flight project, Mercury, is expected to conclude after the MA-9 mission. The program will have involved six manned missions, from 5-min. ballistic flights to as much orbital time as Maj. Cooper can obtain in the coming attempt.

Mercury has succeeded in demonstrating man's ability to function in the space environment and to use his judgment in flying a capsule. Besides its technological successes, Mercury has sold the Administration and Congress on the value of the space program as it relates to national morale and international prestige.

Technologically, Mercury has established the framework for Gemini, and has verified the wisdom of using test pilots as astronauts.

A capsule and Atlas launch vehicle are ready for a Mercury Atlas-10 mission if NASA is not fully satisfied that MA-9 has obtained the full store of data possible from the Mercury system. MA-10, if flown, probably would take place late next summer or early fall.

To break the booster-limit straitjacket on U. S. spacecraft size, like the case of Mercury, NASA is developing the Saturn family of high-thrust vehicles.

NASA is requesting $1.1 billion in Fiscal 1964 to develop the Saturn family to be used in Apollo, in addition to buying vehicles already developed or ready for operational use. The program, and its funding levels in thousands:

System	Fiscal 1964	Fiscal 1963
Saturn 5	$733,000	$329,600
Saturn 1	93,000	190,700
Saturn 8	68,600	16,900
F-1 engine	54,100	50,900
J-2 engine	48,200	44,500
Rt10 A3 engine	32,600	32,600
H-1 engine	5,200	5,300
Propulsion technology	22,500	7,900
Vehicle technology	16,900	6,800
Operations technology	7,300	3,000
Range support/ instrumentation	41,000	0,000
Salaries, in-house operation	151,000	116,700
Total	$1,274,500	$817,800

Manned Space Flight Schedule

Mission	Date
Mercury Atlas-9	May–June, 1963
Gemini ballistic	December 1963
Gemini two-week	1964
Gemini rendezvous/docking	1964–65
Apollo ballistic	1963–64
Apollo earth orbit	1965–66
Apollo earth orbit/rendezvous	1966–67
Apollo circumlunar	1967
Apollo lunar landing	1968

Key milestones scheduled during the next year are preliminary flight rating tests for the F-1 and J-2 engines, both under development by Rocketdyne Division of North American Aviation. Five clustered F-1s will power the Saturn 5 booster, which will launch Apollo on both circumlunar and lunar landing missions. A five-engine J-2 cluster will power the second stage of the vehicle, and a single J-2 will power the third stage.

Both engines have experienced problems of rough combustion during development. In the J-2 the problem was met by redesigning the injector, adding a combustion suppressor. The F-1 problem has not been solved.

NASA has set a demanding man-qualification program for the F-1, which involves 75 consecutive full duration runs. The J-2 qualification program includes 425 separate engine component tests.

The Saturn flight test program has been characterized by complete success in the first three launches in a 10-vehicle testing program. One more Block 1 Saturn with an inert S-4 second stage is to be fired this spring. In Fiscal 1964, a Block 2 Saturn with live booster and second stage will be launched every three months.

Tenth vehicle in the test program will have the first Chrysler produced booster stage. Payload for Saturn test vehicles starting with the fifth will be Apollo boilerplate or prototype capsules.

The Douglas S-4 stage is powered by a cluster of six Pratt & Whitney RL10-A3 engines. A battleship cluster of six major engine components was fired for the first time last Aug. 17, and a full duration, 435-sec. firing of the cluster was accomplished six weeks later.

The second member of the Saturn family, now called 1B, is being designed solely for Apollo. It has the capability to launch a full-sized Apollo spacecraft into earth orbit where the structure and components can be qualified in long-duration flight. It will also test the Douglas S-4B stage, which is the 1B second stage and the Saturn 5 third stage. The booster is the same as the Block 2 Saturn 1. An eight-engine cluster of Rocketdyne H-1 engines, each

Technicians complete the installation of a communication satellite thermal model in the Bendix 20' x 27' vacuum chamber by connecting thermocouple leads to a terminal panel. Tests verify the thermal balance of the configuration in outer space conditions. The satellite shape, the strategic location of electronic equipments and thermal coatings in critical areas maintain satellite temperatures within limits necessary to provide maximum operating efficiency.

producing 188,000 lb thrust. Block I H-1 engines have a 165,000 lb thrust rating.

Test program for Saturn 1B involves only four flights, all with live stages and all carrying Apollo developmental spacecraft.

Test program for Saturn 5 has not yet been defined, but it will probably consist of eight flights, the last four of which would have live upper stages.

Until early last year, NASA was hopeful that it could organize a headquarters staff capable of assuming the integration, checkout and systems engineering responsibilities associated with current and future manned space flight missions. The agency could not attract the talent it needed for these tasks except on the management level.

As a result NASA contracted with General Electric and Bellcom to perform these functions.

Integration and checkout for Apollo has become a major program to assure that everything produced by the prime contractors and the several thousand subcontractors and suppliers fits the system mechanically and functionally. The GE contract consists of three fundamental aspects:

- **Integration**—identifying and documenting equipment and procedures which involve more than one contractor.
- **Checkout**—provision of a standardized means of checkout systems analysis, and designing and building the launch control checkout equipment. Hardware items for checkout are being bought with Fiscal 1963 money.
- **Reliability**—a joint program being undertaken by GE and several NASA centers. Objective is to assess reliability levels, and to establish requirements for redundancy and testing.

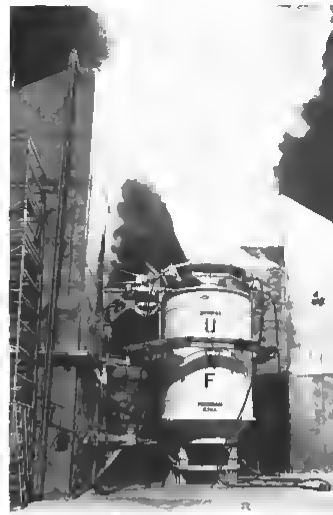
Rapid evolution of the space program has brought with it the need to determine exactly where the country is going in manned flight, and what means will be used to get there. The Systems Engineering Directorate in NASA has the task to provide this information and is aided by Bellcom in both approved and planned programs.

NASA's decision to use the lunar orbit rendezvous technique for the manned lunar landing mission was based on systems office studies and this office also developed the central Apollo document called Apollo Systems Specifications. This document defines the flight missions, requirements for each subsystem, and the subsystem responsibilities.

Studies for future missions are focused on space stations, lunar bases and manned planetary expeditions. NASA anticipates that it will select the post-Apollo manned mission within a year on data which evolves from these systems studies.

CONSTRUCTION has begun at Cape Canaveral of a roadway to the Integration Transfer and Launch System site for USAF's Titan 3. Assembly buildings and launch control center for Titan 3 will be in the middle of the Banana River on man-made islands, and connected to the launch pads by a rail network.

CONVERSION OF COMPLEX 20, a former Titan 1 pad, is under way for handling launch of the Titan 3A. This is the Titan 2 core, augmented with a transtage, but without the two 120-in. solid propellant strap-on boosters.



SEGMENTED solid propellant rocket motor is fired as part of United Technology's 120-in Titan 3 program.

DOD Balks Most Military Space Expansion

Military space activity reducing the intelligence imbalance between U. S. and Soviet Russia continues at a rapid pace, but other military space programs remain stymied because they have failed to receive top-level Defense Department and Air Force support.

Two basic parts comprise the U. S. defense space effort, a broadly based intelligence-gathering program which is successfully exploiting the most advanced concepts in sensors and space flight technology, and the segment including communications and navigation satellites which is openly reflected in the budget.

Pace of the intelligence activity is seen in the number of military launches registered with the United Nations during 1962. There were 33 successful U. S. military launches in the past year, 12 more than were flown by the National Aeronautics and Space Administration.

Greatest share of the defense space program is assigned to the USAF Systems Command, with the Navy's Transit navigation satellite program the only approved non-USAF military space activity. Air Force early this year decided to concentrate its emphasis on three primary systems:

- **Military orbital development system (MODS),** a space station concept.
- **Rendezvous-Inspector system.**
- **Secure communications satellite.**

All other funded projects, programs, and conceptual and feasibility studies are geared directly to these three projects or to the intelligence effort.

Because MODS and Inspector are manned, these projects come under the scope of the Gemini planning board, a joint Defense-NASA board responsible for coordinating all manned space flight activities. Although MODS is considered by USAF to be the top priority item in its space program, the service has been unable to convince DOD of its necessity. As a result, USAF will try to buy into NASA's space station program, which is being actively studied now. The civilian agency hopes to define a space station development plan before the end of the year.

For the same reason, USAF is buying a portion of the NASA Gemini program to take up the slack resulting from cancellation of the Saint unmanned inspection satellite and the manned Saint 2 Inspector satellite. USAF has developed plans in which Gemini would be the basis for the Inspector satellite, and a ferry vehicle for MODS personnel and supplies.

Extent of USAF participation in Gemini has not been determined, but Air Force is pushing hard to shift X-20 Dyna-Soar money to the Gemini program. Indications are that the X-20 program will be canceled or reduced to a study later this month. Defense Secretary Robert S. McNamara's visit to the Boeing plant in Seattle as a part of a personnel survey of the manufacturing aspects of the program wound up a Defense Department evaluation of Dyna-Soar carried on for the past 18 months.

Reactions are mixed even in Systems Command over the impact of cancelling X-20. Total program cost is estimated at $800 million, and the argument centers around whether the technology Dyna-Soar will provide is worth this amount. Although the boost glide vehicle probably could not fly until 1966 or later if it is continued at its present pace, it will provide data on maneuvering during re-entry and on radiation cooled structures not available from other space flight programs.

Gemini Accord

One of the central reasons USAF wants to extend Gemini as its own program is to obtain management experience in manned space flight. Terms of the Gemini agreement call for joint experiment planning, joint flights and in-flight tests and coordinated analysis of results — under NASA management. Jointly, USAF and NASA will obtain rendezvous, docking and extended weightless flight experience in the Gemini program.

A separate USAF program could make Gemini an operational interceptor using sensors, cameras and other reconnaissance equipment in the basic two-man Gemini spacecraft.

The military communications satellite program was reoriented last May, resulting in the cancellation of Advent and start of two new programs: a random-orbiting medium altitude system, and a synchronous system. USAF was given responsibility for developing the satellites, and Army the ground network.

Pacing item in the communications satellite programs has not been technology, but the failure of Defense Research and Engineering to act on a program development plan. Net result is that hardware contracts are still not awarded, and the first flight date has slipped from early next year into 1965. First program development plan was submitted last September, and it has been under fairly continuous revision since. Overlay of management responsibility of the communications satellite program is illustrated by the fact that after passing through military channels the program must undergo 57 separate approval steps in Defense Research and Engineering.

A 6-man plan is expected in late spring, and proposal requests for subsystems are expected to be issued at that time. Technical approach is to use state-of-the-art items wherever possible, excepting probably some advanced concepts in traveling wave tube technology. There has been criticism that the first military communications satellite will not be secure, and will not be as advanced as the American Telephone & Telegraph Telstar satellite. Although USAF concedes this, the service insists that the operational system will not have these drawbacks.

Launch Vehicles

The medium altitude system will consist of a large number of relatively small satellites launched by Thor or Atlas Agena combinations. Each vehicle will carry four or more satellites that will be ejected randomly at an altitude of about 5,000 mi. In the synchronous system, three equidistant satellites would be placed in orbit at 22,300 mi. altitude. Launch vehicle could be a Titan 3-A.

Air Force last year conducted an extensive space science and technology program, but the service finds it difficult to disseminate the results in view of the Defense Department secrecy edict on its space activities. Although space capsule recovery is considered a prime objective in the USAF satellite program, the service no longer is allowed to disclose how many of its capsules were ejected from orbit and recovered.

The secrecy directive, issued last Mar. 23 and itself classified secret, has effectively reduced the flow of scientific results, or at best has delayed publication of the results. Its major provisions are a ban on press coverage of launches, elimination of names such as Discoverer, Midas and Samos and assigning weapon system number designations to projects, restriction of all military space information to those "with a need to know," and release of scientific information only after it has been screened for security.

Statistically, USAF in 1962 launched 65 scientific experiments on board satellites broadly designed to measure upper atmosphere density, micrometeorite populations, natural and artificial radiation, electron and ion densities, magnetic fields and galactic radio noise. Air Force developed a standardized research payload module to fit into the Agena stage, and successfully launched 13 of these modules during the year.

Atmospheric studies were conducted by instruments carried aloft in 50 sounding rocket and probe flights, launched mainly from the Eglin Gulf Test Range and White Sands Missile Range. These rocket launches obtained data on chemical properties, kinetics and composition of the upper atmosphere. Twelve nuclear emulsion payloads were launched and recovered providing information on energetic particle flows and cosmic rays.

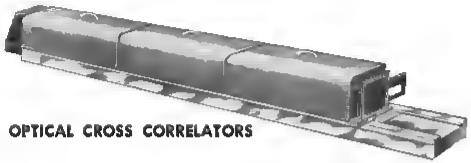
New Studies

Other scientific experiments last year included six flights of a standing wave impedance probe and five flights of a plasma probe experiment.

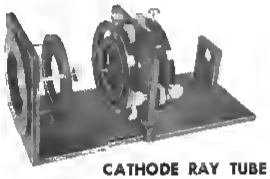
USAF will extend its investigation of the atmosphere in 1963 with the launch of approximately 700 balloons designed primarily to measure ozone concentrations as they differ with seasons and altitude.

In the area of technology, USAF has established a three-year program to study

GO TO CONDUCTRON

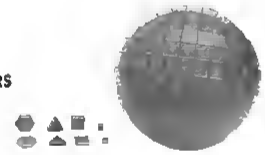


OPTICAL CROSS CORRELATORS

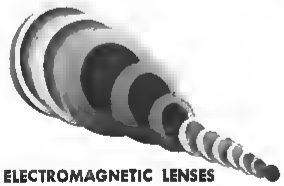


CATHODE RAY TUBE HOLDERS

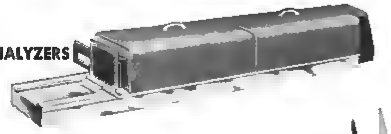
VIDEO AMPLIFIERS



RADAR ABSORBING MATERIALS

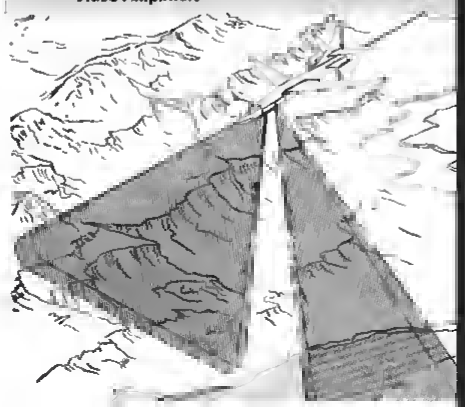


ELECTROMAGNETIC LENSES



OPTICAL ANALYZERS

FINE RESOLUTION RADAR SYSTEMS



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W. Schwartz
Weapon System Vulnerability, Re-Entry Systems

W. C. Barker
Future Weapon Systems Radar Cross Section

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- Fine Resolution Radar Techniques
- Network Analysis and Synthesis
- Systems and System Analysis
- Optical Image Processing
- Information and Communication Theory
- Electromagnetic Theory (Radiation, Propagation, Scattering)
- Plasma Physics
- Detection Theory
- Numerical Analysis
- Radiometer Techniques
- Antennas
- Management Techniques (Including PERT)
- Electromechanical Devices

FOR Production of . . .

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LOCKHEED Propulsion's Apollo launch escape motor is placed in test stand.

advanced ballistic re-entry systems (ABRES), in which 23 contractors will participate. Major phases of the program are development of advanced materials maneuverable cones and decoys and penetration aids. Atlas F standard launch vehicles will carry the payloads on ballistic trajectories from both the Atlantic Missile Range and Vandenberg AFB.

Status of major USAF space flight programs:

• **ICBM alarm satellite,** formerly called Midas, using infrared sensors to detect ballistic missile launches by sensing missile exhaust radiation. Midas was originally scheduled to become operational next year, but the program schedule proved too ambitious, satellite design too complex and insufficient data was available on background earth radiation. As a result, the program was reduced to experimental status early this year, and components are now being tested in orbit.

• **ASSET,** the aerothermodynamic/elastic structural systems environmental test series. Program, with McDonnell

as prime contractor, originally was scheduled to begin a year ago, but the payload became too heavy for the planned Scout launch vehicle and was shifted to Thor Delta and Thor vehicles. First test flight is scheduled for next August. Four flights are planned of different hypersonic re-entry vehicle models made of various materials.

• **Vela Hotel,** a joint Defense Department Atomic Energy Commission satellite program to develop a satellite to detect nuclear explosions in space. Components are being tested in orbit and as rocket payloads.

Air Force made a concerted attempt during the past year to standardize its launch vehicle family because of a philosophy that the vehicle must be clearly defined to provide some basis for incentive contracting in payloads. The standard launch vehicle objectives are to increase reliability and production rates along with a cost reduction.

Vehicles in the standard launch vehicle category are Thor, Atlas, Agena and Titan 3. The Titan 3 is a two-vehicle system, consisting of the 3-A and 3-C. Titan 3-C, a Titan 2 core with two 120-in. segmental solid motors strapped to its sides, is expected to have its first flight in 1965 and to be qualified to carry manned spacecraft a year later.

The comparatively brief development program is possible because the engines are being tested in both Titan 2 and Minuteman development flights.

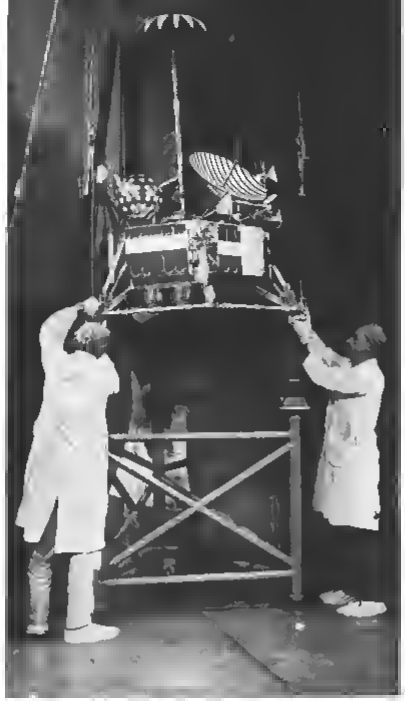
Titan 3 A schedule calls for a first flight in autumn of 1964. Vehicle is basically a Titan 2 with a third stage called the transtage. Upper stage is a two-nozzle 16,000-lb. thrust engine.

First Phase 2 contracts for development of Titan 3 were awarded early this year after a protracted program definition effort and review that took nine months.

The program is the first major one in the Air Force to use incentive contracts during initial development and a great deal of the long definition period was due to cautious and complex negotiation over incentive fee provisions.

Technical definition was carried out in Phase 1 studies that were completed in early spring of 1962. During this phase it was determined that the transtage would be a necessary addition to the Titan 2 core.

First Phase 2 contract signed was with United Technology for the 120-in. solid booster development. Late in February, the contract with Martin Marietta for the Titan 2 core was completed. Aerojet General Corp. is contractor for Titan 2 engines and AC Spark Plug for guidance. Originally, the launch complex at Cape Canaveral was to consist of three new pads, but one planned for filled land in the Banana River was eliminated in the Phase 2 negotiations.



HUGHES SURVEYOR (left) is designed for soft lunar landings. Ranger 5 payload (right) was successfully boosted out of parking orbit around the earth but failure to make a midcourse correction caused it to miss the moon by 450 mi.

Space Science, Research Effort Grows

By Alfred Ahbrando

Washington—Space science and research under way by the National Aeronautics and Space Administration is growing to the point where the $1.2 billion requested in this category for Fiscal 1964 is more than the $964 million NASA spent for all its programs in Fiscal 1961—including the Mercury manned flight program.

Bulk of U. S. spending for space science and research is done by NASA, whose comprehensive flight program ranges from use of small sounding rockets for studies of the near-earth environment to heavy and complicated spacecraft for missions to the moon and the planets.

Science programs are managed by NASA's Office of Space Science, whose budget request for Fiscal 1964 is $754.7 million. Research programs are formulated by the Office of Advanced Research and Technology, for which NASA is asking $463.8 million.

Best-known and most costly of the scientific flight programs are the lunar, planetary and interplanetary missions. These include the Ranger, Surveyor, Mariner and Pioneer programs.

Ranger and Surveyor, highly automated television-equipped spacecraft for study of the lunar surface, were originally planned as basically scientific efforts. But with the emphasis on manned flight, Ranger and Surveyor are now described by NASA as scientific programs which will support Apollo manned flights to the moon.

NASA has spent well over $100 million on the Ranger program but of the five flights so far none was successful.

The first two Ranger flights in 1961 were tests of the spacecraft. The flight plans called for the spacecraft to be sent on 600,000-mi. elliptical flights which would take them into deep space but not near the moon. Purpose of these long flights was to give the spacecraft attitude control system a long workout and to test the communication and command capability of deep space tracking facilities. In both flights the Agena stage on the Atlas Agena B launch vehicle failed to kick the spacecraft out of the parking orbit.

Rangers 3, 4 and 5 were launched in 1962. Each carried a television camera, seismometer and gamma ray spectrometer. The camera was to televise more than 100 pictures of the lunar surface to earth as the spacecraft approached the moon, the spectrometer was to give some clue as to the chemical makeup of the moon's surface, and the survivable seismometer an indication of the moon's interior structure.

In the Ranger 3 flight, excess velocity imparted by the launch vehicle caused the spacecraft to pass ahead of the moon. Atlas Agena performance was good on both Rangers 4 and 5, but troubles developed in the spacecraft. In the Ranger 4 flight, the spacecraft was injected on its lunar trajectory so accurately that it impacted the moon without a midcourse correction but failed to transmit pictures. Because of a failure in the power system on the Ranger 5, midcourse corrections could not be sent to the spacecraft and it missed the moon by about 450 mi.

As a culmination of various failures, Ranger 5 brought an investigation of the program. Management of Ranger at the Jet Propulsion Laboratory, which has responsibility for NASA's lunar and planetary programs, was changed. It was also decided to subject Ranger 6 to extensive systems analysis and ground testing to destruction at JPL and, as a result, scheduling of Ranger flights this year is undergoing revision.

Ranger spacecraft have been built at the Jet Propulsion Laboratory, Pasadena, Calif., but an industry contractor is expected for future spacecraft, possibly beginning with Ranger 7. (AW Feb. 25, p. 39)

Ranger program costs, which include personnel and operation of facilities, were $64.1 million in Fiscal 1962, $79.8 million in Fiscal 1963 and will be about $91 million in Fiscal 1964.

A major factor in the Surveyor program, which contemplates both soft lunar landings and lunar orbiters, and the Mariner Mars mission in 1965 is development of the Centaur rocket. Centaur uses Atlas as the first stage and a 30,000-lb. thrust hydrogen-oxygen-propellant upper stage.

In the first Centaur flight on May 8, 1962, a structural failure in the Centaur stage caused an explosion 54 sec. after launch. Extensive testing and evaluation are now under way and another test flight is scheduled about mid-year. At best, Centaur won't be ready for operational flights until late 1964 or early 1965.

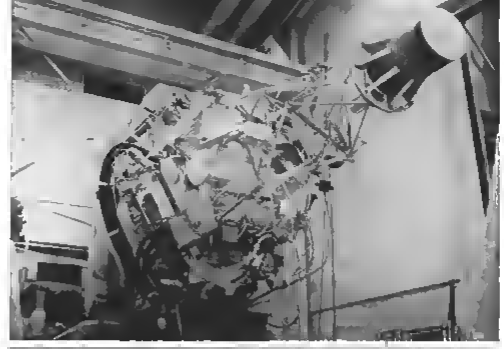
If the next few Centaur test flights go well, NASA will push ahead with plans to use it as the booster for Surveyor. If development problems aren't solved soon, the space agency probably will start looking at Titan 2 and Saturn as replacements. A change in launch vehicles could cause further delays in the first Surveyor flights, originally scheduled for 1963 and now for 1964.

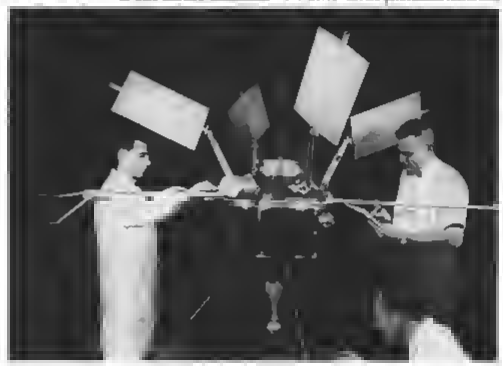
Surveyor, being developed and built by the Hughes Aircraft Co., will serve as a remote observation post for studying the lunar topography and examining the texture of the moon's surface. It will also function as a stationary laboratory for measuring the physical and chemical characteristics of the lunar surface and subsurface.

Equipment which will perform these tasks includes high resolution television cameras, drills, microscopes, an X-ray spectograph, X-ray diffractometer and gas chromatograph, a seismograph system, a magnetometer, a plasma probe, and radiation detectors. Not all of these instruments will be carried on each Surveyor. They represent the kinds of instruments NASA hopes to land on the moon during the Surveyor soft-landing flight series.

Surveyor received $39.6 million in Fiscal 1962, $62.6 million in 1963 and the budget request for Fiscal 1964 is $98.7 million.

First successful flight in NASA's planetary program was that of Mariner 2, launched on Aug. 27, 1962, from





MARINER 2 package (top, left) successfully transmitted data during a Venus flyby. Britain's first satellite, Ariel 1 (bottom, left), was placed in orbit by NASA last year. Republic re-entry body (right) will be used in Project Fire tests.

But Failures Beset Lunar Missions

Cape Canaveral on an Atlas Agena. The 447-lb. spacecraft, aimed at a point 10,000 mi. from the surface of Venus, flew by the planet on Dec. 14 at a distance of 21,594 mi.

Flight of Mariner 2 confirmed earlier data gathered on magnetic fields and energetic particles in interplanetary space and sent back to earth information on the magnetic field in the vicinity of Venus and on the temperature of the atmosphere and surface of the planet. The magnetometer on Mariner indicated there is no magnetic field or only a very weak one.

Data from the radiometers aboard Mariner 2 indicate a uniform surface temperature of 800F on both the sunlit and dark sides of Venus. The radiometer experimenters also report that the atmosphere which veils the planet is 17-mi. thick, consists of condensed hydrocarbons and ranges in temperature from 200F at the base to −65F at the top.

Following the flight of Mariner 2, NASA announced it would pass up the next opportunity for a Venus mission in March, 1964, and concentrate on Mars flight in the fall of 1964.

Primary purpose of the Mars mission is to determine whether there is life on Mars. Experiments under consideration for the 1964 mission include an optical system for taking and transmitting pictures of the Martian terrain, an ultraviolet spectroscope, an infrared spectrometer and a magnetometer.

Later Centaur-launched missions probably will carry a much larger spacecraft of about 1,300 lb. with an ejectable landing capsule. The capsule would carry pressure-accelerometer instrumentation, experiments to determine the nature of the atmosphere and instruments to detect life directly.

Mariner costs were $49 million in Fiscal 1962, $58 million in Fiscal 1963 and $102 million is being requested for Fiscal 1964.

NASA is asking Congress for $15.7 million in Fiscal 1964 to build and fly a series of 120-lb. spacecraft on long interplanetary missions beginning in late 1964. The program would continue the kind of interplanetary investigations made with Pioneer 5 and some of the Explorer flights.

New Pioneer program calls for flights every six months. Spacecraft will be injected with energy just above that required for escape from the earth in a trajectory that will provide a separation of 30,000,000 mi. between the earth and spacecraft six months after launch. Spacecraft will be flown in toward the sun and in trajectories away from sun.

Pioneers will carry instruments to gather information on solar flares, magnetic fields, energetic particles and cosmic dust. The NASA Ames Research Center, which will manage the pro-

NASA Accelerates Bioscience Program

Bioscience and human factors programs of the National Aeronautics and Space Administration are finally getting off the ground after more than four years of talk, planning, political buffeting and inaction.

NASA is requesting $41.3 million for bioscience programs in Fiscal 1964, 10 times as much as that sought in Fiscal 1962. The request contains $24.4 million for a biosatellite flight program, $10.8 million for supporting research and technology, and $6.1 for personnel and operation of installations. Biosatellite flight program breakdown shows $11.7 million for the spacecraft and $12.7 million for launch vehicles, proposed on use of the Atlas Agena B. The Ames Research Center is field manager of the program.

NASA's budget proposal specifies that the spacecraft will be stabilized and have retrofire capability for positioned re-entry. The life support system will include a life cell, an environmental control system, biomedical instrumentation, telemetry equipment and a two-gas, sea level atmosphere.

In addition, the life support system will be designed to support a variety of experimental subjects and will have the capacity to support several monkeys in orbit for periods of about two weeks.

Since the first biosatellite flight is not scheduled until late 1964, there is some question of the program's value. By the time the biosatellite is launched, NASA expects to have orbited two men for two weeks or more.

Funding of university studies and development of experiments for Mariner Mars flights in fall of 1964 and in 1965 is included in the exobiology program. The Mars flight in 1964 will not have an ejectable landing capsule. NASA hopes to fly a larger Mariner spacecraft on a Centaur launch vehicle in 1965 and this Mariner B spacecraft would carry an ejectable capsule carrying life-detecting experiments.

Until last year, when Dr. Eugene B. Konecci joined NASA as director of biotechnology and human research, the human factors program was progressing at about the same rate as bioscience activity. He and his associates moved quickly, determined to proceed with hardware development.

Budget for human factors in Fiscal 1964 totals $24.3 million, compared to $14 million in Fiscal 1963 and $4.9 million in Fiscal 1962. Of the $24.3 million for Fiscal 1964, $6.8 million is for life support systems, $5.6 million for man-machine integration, $4.9 million for human research and performance, $900,000 for advanced concepts, and $6.1 million for personnel and operational costs.

One of the most important programs in the human factors area is development of long duration life support systems for manned space stations and planetary flights. First of a series of contracts for these life support systems (AW Jan. 14, p. 28) has been awarded to the Boeing Co. The contract is for development and demonstration of a system which will support five men for 30-60 days.

Proposals on a life support system that would sustain a four-man crew 6-12 months are now being evaluated by NASA. Other contracts will be let this year for development of breadboard systems designed to support crews for 3-6 months and for a year or more. Other areas the human factors group plans to push ahead include:

- Development of biological fuel cell systems and psychophysiological monitoring systems. The fuel cell will convert human wastes into power and the psychophysiological monitoring will be used for selecting and checking ground and flight crews.
- Improvement of space suits.
- Fundamental studies of the heart and blood circulation to gather information needed for monitoring and understanding man's survival and performance in space.
- Isolation and confinement studies.
- Effects of various concentrations of oxygen and nitrogen at different pressures.
- Continuation of studies on pilot operation in planetary and rendezvous missions, using simulators at the Langley and Ames Research Centers.
- Development of closed ecological life support systems with a photosynthetic gas exchanger, under way at the University of Minnesota under a contract with Ames.

NASA is asking for a total of $21.6 million for space medicine in support of the current manned flight program. Breakdown of this request includes $8.1 million for experimental studies, $3.9 million for crew systems, $3.1 million for biomedical in flight experiments, and $1.5 million for medical operations.

Detailed explanation of the space medicine program in the Office of Manned Space Flight is only three pages long—one of the shortest justifications in the entire four volume budget.

Much of this money will go into development of systems which are part of the Gemini and Apollo spacecraft. Funds for medical operations include such items as frequent examination of astronauts, maintaining medical staffs at Houston and Cape Canaveral, and funding of the large medical operation required around the world on Gemini flights.

1963 NASA Launch Schedule

Mission	Launch Vehicle	Orbit (mi.)	Payload Wt (lb.)
Scientific Satellites:			
S-6 Atmospheric Structures	Delta (2 launches)	460–155	400
S-48 Topside Sounder	Scout	740–500	110
S-66 Polar Beacon	Scout	600	70
Solar Observatory	Delta (2 launches)	300	440
S-52 Ionospheric (UK)	Scout (2 launches)	1,000–230	165
IMP Monitor Probe	Delta (2 launches)	172,000–126	125
S-55 Micrometeoroid Detector	Scout	620–240	135
Geophysical Observatory	Atlas Agena B	69,000–170	1,000
Communications Satellites:			
Syncom	Delta (3 launches)	22,300	86
Relay	Delta (2 launches)	3,000–900	125
Telstar	Delta (1 launch, 1 backup)	3,000–600	175
Echo 2	Thor Agena B	650	650
Weather Satellites:			
Tiros	Delta (2 launches)	400	285
Nimbus	Thor Agena B	500	600
Materials Technology:			
Re-entry	Scout (2 launches)	Ballistic	360
Fire	Atlas with X259 stage	Ballistic	185.5
Manned Flight:			
Mercury Atlas-9	Atlas	100–150	3,100
Manned Flight Development			
Vehicle tests	Saturn 1 (3 launches) (1 with Apollo Boilerplate)	Ballistic	
Apollo Boilerplate	Little Joe 2 (2 launches)	Ballistic	10,000
Gemini 1	Titan 2	Ballistic	7,000
Other:			
Electric Engine (SERT)	Scout (2 launches)	2,500 (elli.)	325
Vehicle Tests	Centaur (2 launches)	300 mi.	8,500 lb.
Booger Laser Photography	Atlas Agena B	Lunar Impact	727

gram, will hold an industry competition for construction of the spacecraft.

Emphasis in the Pioneer series will be on simplicity and reliability. Unlike the Mariner and Ranger spacecraft, which have rather complex attitude control systems, Pioneer will be spin stabilized. One purpose of the program is to insure a relatively high percentage of successful flights into interplanetary space as a hedge against a high failure rate for the more complicated Ranger, Surveyor and Mariner spacecraft.

Exploration of the earth's environment—probing properties of the ionosphere, atmosphere, magnetic field, radiation belts, gravitational field and structure of the earth itself—falls into the classification of geophysics and is conducted through experiments flown on sounding rockets, Explorer satellites, monitoring probes and the large observatory satellites.

Explorer satellites, which weigh about 100 lb., are flown on Scout and Thor Delta rockets. Seven of these earth satellites are to be launched in 1963. Cost of these flights will be about $20 million, comparable to expenditure last year.

Launch of about 80 sounding rockets or geoprobes in 1963, most of them from NASA's Wallops Island, Va., launch facility, will cost about $19.6 million. Rockets used in these flights are the Nike Cajun, Nike Apache, Aerobee, Javelin and Journeyman.

First of the Orbiting Geophysical

Observatories, being developed for the NASA Goddard Space Flight Center by Space Technology Laboratories, is scheduled to fly this year. The geophysical laboratory, which will weigh 1,000 lb., is to be launched on an Atlas Agena into a highly eccentric orbit passing through the earth's natural radiation belts. Twenty experiments have been chosen for this mission to study solar and galactic radiation, Van Allen belt radiation, the earth's magnetic field, the ionosphere, upper atmosphere, micrometeoroids and radio noise associated with the galaxy.

Second geophysical observatory is scheduled to be launched on a polar orbit in 1964. A Thor Agena rocket will be used for this launch and the flight will be programed to take the satellite over the polar regions at low altitude to obtain data on the atmosphere and ionosphere. NASA proposes to continue geophysical observatory flights through a complete 11 year solar cycle. Cost of the geophysical laboratory program in Fiscal 1964 will be about $62 million.

NASA also plans a series of geodetic satellite launches, with the first launch scheduled in 1964. To carry out this program, which the agency took over from the Defense Department, NASA is asking $6.2 million in Fiscal 1964.

First Orbiting Solar Observatory, OSO 1, was launched last April and returned much information on solar activity. The spacecraft, built by Ball Brothers Research Laboratory, Boulder, Colo., did not have the capability to relate fluctuations in the solar spectrum to particular sunspots or other activity on the sun but OSO 2, to be launched during the first half of 1963, will be able to accomplish this objective. The spacecraft also will carry an occulting disc for obscuring the main body of the sun from the instruments' field of view so that studies can be made of the sun's corona or outer atmosphere.

Additional flights are planned with OSO type spacecraft at six month intervals. Estimated spacecraft, booster and personnel costs for Fiscal 1964 total $20.6 million.

First of the Orbiting Astronomical Observatories is scheduled to be launched in 1965. The 3,600-lb., 10-ft. diameter spacecraft, built by the Grumman Aircraft Engineering Corp., will be launched on an Atlas Agena spacecraft. The first OAO will have a coarse control system capable of pointing the spacecraft in any desired direction with an accuracy of one minute of arc. Subsequent spacecraft will have the capability of pointing within one second of arc.

First OAO will carry two major experiments, one pointing from each end of the spacecraft. The Smithsonian Astrophysical Observatory is preparing an experiment which will use four 12-in. telescopes with a broad-band television ultraviolet photometer to map the sky and record the brightness of 200,000 stars.

The University of Wisconsin is preparing the other major experiment, which will use four 8-in. telescopes, a 16-in. telescope, and two spectrometers to gather information on the structure and properties of several hundred of the brightest stars and nebulae.

Second OAO, to be launched in 1965, will carry a 36-in. Cassegrain telescope with a large aperture spectrophotometer. The telescope will be focused on several thousand selected stars and nebulae to provide detailed data on temperature, pressure, density and chemical composition. Third OAO, to be launched in 1966, will carry a Princeton University experiment package designed to gather information on the chemical composition of interstellar gas and dust, its temperature, state of ionization, velocity, position and relative proportion in interstellar space.

About $138 million will be spent or appropriated for the Orbiting Astronomical Observatory program in the three-year period ending with Fiscal 1964.

Of the $463.8 million requested for advanced research and technology in Fiscal 1964, $111.4 million is for development of advanced space vehicle systems. Proposed program includes studies on spacecraft aerothermodynamics, spacecraft loads and structures, space vehicle environmental factors, launch vehicle loads and structures, and space vehicle design criteria.

During Fiscal 1964, emphasis will be placed on research into heating effects of flights up to the 45,000-fps. velocities expected on return from interplanetary missions.

A number of re-entry flight tests from Wallops Island, Va., and Cape Canaveral, Fla., are scheduled this year. The Scout rocket will be used in the Wallops launches and Atlas will be the booster for Project Fire tests from the Cape. In the latter, Atlas will launch a blunt shaped re-entry vehicle on an ICBM trajectory. In the re-entry vehicle, an Antares solid rocket will fire downward, bringing the re-entry velocity to 37,000 fps.—to the level of Apollo re-entry velocities.

One or more Scout-launched meteoroid satellites will be flown this year and in 1964 and a 4,000-lb. umbrella or wing-like structure will be boosted into orbit by Saturn to determine the probability of meteoroid impacts.

Budget request for advanced guidance and control, tracking, communications, instrumentation and data handling systems is $54.5 million. Fiscal 1964 funding will be used to continue research on superconductive magnetic and electrostatic gyros and accelerometers, laser-type guidance sensors and development of techniques to permit use of lasers in communications.

Biggest single item in the research budget is $118.9 million for nuclear rocket development. This program is conducted jointly by NASA and the Atomic Energy Commission and includes three major projects:

- **Kiwi**, development and testing of a hydrogen-cooled breadboard nuclear reactor.
- **Nerva**, development and flight testing of a nuclear rocket engine.
- **Rift**, design, development and flight test of a Nerva-powered stage for launch by Saturn.

Although the next firing in the Kiwi program is indefinite because of problems in the reactor core, NASA is still maintaining that the first static test of the Nerva engine will be in 1965. Nerva is being developed by Aerojet General and Westinghouse.

Funds requested for research on chemical propulsion processes total $35 million. Study areas include high energy engines using a fluorine-hydrogen fuel, work on high expansion ratio nozzles, better chamber and nozzle materials, improved pump and valve systems, higher specific impulse solid rocket fuels, hybrid chemical-solid fueled rockets.

Budget request for nuclear-electric propulsion and power sources is $35.5 million, compared to $28 million in Fiscal 1963.

NASA's research program in nuclear-electric power and propulsion will continue work on ion engines and the Snap-8 power system. Snap-8 is being designed to provide a minimum of 35 kw. for 10,000 hr. or more. Ion and colloid thruster engines under development produce thrusts ranging from 0.1 lb. to 10 lb. at specific impulses of 3,500 to 10,000 sec. or greater.

Other work on advanced propulsion systems includes development of electrothermal engines and plasma acceleration engines. Mission analysis studies will be undertaken this year to determine the requirements for electric propulsion systems and payload capability of early and advanced spacecraft powered by such engines.

Funding asked for aeronautical research in Fiscal 1964 totals $451 million.

The principal items are for continued work on vertical or short take-off and landing aircraft and on supersonic transports and hypersonic aircraft.

Vostoks, Cosmos Build Soviet Space Gains

By Evert Clark

Soviet Russia's 10-to-1 lead over the U. S. in manned space flight experience may be widened even further in 1963 as a result of the highly successful group flight of Vostoks 3 and 4 and the intensive Cosmos scientific satellite program.

In spite of the great expansion of the U. S. manned program since the first Vostok flew two years ago, Russia is in a position to exploit its lead in time and booster power for many months before the U. S. can begin to explore the techniques of rendezvous and multiman flight that are essential to lunar and planetary landings.

Russia has just completed by far its most active year of space launchings—12 successful Cosmos shots fired at an average rate of one every three weeks a successful Mars probe, the Vostok group flight, and apparently at least five failures in attempts to launch probes to Venus and Mars.

Discounting the known and concealed failures Russia's rate of successful launchings in 1962 was more than double that of the previous most active year—1961—and far ahead of any earlier year. In 1960, Russia launched three test versions of the Vostok but with only one success. In 1959, she launched three lunar rockets, in 1958, only Sputnik 3, and in 1957, Sputniks 1 and 2.

What the next step will be in the Soviet manned space flight program is difficult to predict. The group flight of Vostoks 3 and 4 caught most Western observers by surprise. Multimanned flight was considered a good possibility, but a practice rendezvous with precisely matching orbits was not.

There are indications in Soviet discussion of this flight that more group flights, possibly involving more than two vehicles are planned. One extensive review of the goals and results of the first group flight listed as a major scientific and technical achievement the perfecting of "the system of terrestrial means for controlling several spaceships simultaneously in flight in orbits close to one another."

Almost all Soviet discussions of manned flight to the moon and planets indicate that the manned vehicle would be launched from an earth orbit after rendezvous and assembly had been accomplished there. Since the U. S. decision to concentrate on lunar orbit rendezvous rather than rendezvous in an orbit around the earth, articles by Soviet scientists and engineers have also discussed this method as a possibility.

In any case, rendezvous is a key step. And Russia began to probe the human and mechanical depths of it at least 18-24 months before the U. S. was likely to begin.

Significance of manned flight in space can not be measured in terms of flight hours alone, but the number of hours of experience compiled is a useful yardstick from the standpoint of judging man's ability to withstand the combined stresses of prolonged flight, his ability to work under these conditions, the useful lifetime of the spaceship, and the integration of the ground control and airborne elements of the system.

In this area, the Soviet lead is considerable, regardless of whether it is more or less than the 10-to-1 ratio of hours in flight. With Yuri Gagarin's flight of 1 orbit, Gherman Titov's 17 orbit flight, Andrian Nikolayev's 64-orbit flight and Pavel Popovich's 48-orbit flight, Soviet cosmonauts have amassed 192 hr. 06 min. of flight in space. This is in contrast to 19 hr. 06 min. piled up by the United States in two suborbital ballistic flights by Alan B. Shepard and Virgil I. Grissom, the 3 orbit flights by John H. Glenn and Scott Carpenter, and Walter M. Schirra's 6-orbit flight.

Since both Soviet and U. S. launching crews have long ago demonstrated the ability to handle complex, time-limited countdowns and precise trajectory control, it is perhaps the biomedical area of space flight that benefits most from prolonged flights. Biomedical interest is in whether a man can survive and perform in space and for how long. This also is the key to all manned missions in space, both military and civilian.

May Gherman Titov's 25-hr. flight in August, 1961—the longest until that time by a factor of five—gave Russia and the U. S. some concern that prolonged weightlessness might produce effects that did not reveal themselves in a shorter flight. Titov's trouble with his vestibular mechanism caused changes in Russia's methods of training and selecting cosmonauts and dictated several of the biomedical experiments performed in the Nikolayev-Popovich flight (AW Aug. 20, p. 26, Aug. 27, p. 36).

The Vostok 3 and 4 flight eliminated this concern, judging by Soviet reports. Accounts published in Russia some time after the flight said that:

The general state and the basic physiological functions of the astronauts remained within normal limits during the whole flight. Thus it has been established that in the conditions of space flight lasting for about 100 hr., a physically healthy man who has gone through the necessary training is capable of withstanding the state of weightlessness quite satisfactorily. The state of weightlessness does not when there is a settled routine cause any noticeable changes in the 24-hr. physiological cycle in the bodies of the astronauts."

Since working capacity "remained at the necessary level at all stages of the flight," according to the Soviet account, "it can be assumed that flights lasting several hundred hours will also be possible for astronauts after the necessary training."

As the Russians are fond of pointing out, the time and distance of Nikolayev's flight were enough to cover a circumlunar flight. All Vostoks so far have carried life support capability for a 10-day flight, the Russians say.

In spite of the surprise that the Nikolayev-Popovich flight brought to the West, less is really known about the Cosmos satellite series than about Soviet manned space flight. Some Western observers believe that, whatever the lesser goals of this series may be, its primary mission is to serve the cause of manned exploration of space. These observers see all of the Soviet space program so far as a carefully planned, skillfully executed effort with a single purpose—manned flight to the moon and later to the planets.

Mstislav Keldysh, president of the USSR Academy of Sciences, said in the publication Soviet Weekly last October that manned flight to other planets is "the most important prospect facing Soviet space explorations."

The U. S. space program originally was sold to Congress and the public as much on the basis of scientific exploration as on the basis of manned space flight. The Eisenhower Administration, in fact, made no provision for the extension of manned space flight beyond the Mercury project in the last budget it prepared before leaving office.

Since the Kennedy Administration took office, however, the manned program has dominated not only the dollars—as it did even under Eisenhower—but has begun to force some subordination of the scientific program to the direct support of manned space flight.

Keldysh listed these other major objectives of the Soviet space program:

- Dispatch of scientific instruments to

West Europe Spurs Space Programs

Multilateral programs designed to give Western Europe a substantial role in space research are expected to take definite organizational form this year. First steps leading toward the launching of European-developed satellites also should be made during 1963.

Officials of the seven-nation European Launch Development Organization (ELDO), which has the initial task of developing a three-stage satellite boost system, hope to obtain parliamentary ratifications of its treaty in time to begin integrated operations during the second half of the year.

Eleven-nation European Space Research Organization (ESRO), concerned primarily with development of satellites and satellite payloads, also requires parliamentary ratification and officials anticipate that this approval will be obtained before the end of the year.

Meanwhile, working through an interim organizational committee, ESRO plans to begin operations this fall with the firing of two French-built Sud Centaure research rockets from the Italian launch site in Sardinia. Britain also is expected to provide four Skylark research rockets, two for firing and two as backups for similar experiments this fall.

Under present planning, first ESRO-developed satellite will be launched by an ELDO booster in 1967.

Within ELDO, Britain will provide an uprated Blue Streak intermediate-range ballistic missile as the first stage, with France supplying the second stage and West Germany the third. Other members and their roles are:

- Australia will make available its Woomera range complex for test and satellite launches. First Woomera Blue Streak test is scheduled for the near future.
- Belgium will be responsible for the guidance system.
- Holland will direct development of the long-range telemetry units required.
- Italy will build dummy payloads for the test vehicles plus an initial series of satellite test systems.

ELDO also is planning to develop an advanced series of booster units as successors to the Blue Streak. These probably will be used to launch some of the later satellites envisioned in ESRO's eight-year program, although there are no formal agreements binding the two agencies to one another, primarily because national memberships in the two are not identical.

Anticipated ESRO members are Belgium, Denmark, France, West Germany, Italy, The Netherlands, Norway, Spain, Sweden, Switzerland and Britain.

SOVIET MARS PROBE was launched on Nov. 2 and is expected to pass Mars about mid-May (AW Jan. 7, p. 33). Solar panels extend on either side of the vehicle.

the surface of the moon and the planets

- **Establishment on the moon** and planets of "long operating scientific stations." Russia has not admitted launching any payloads to the moon since late 1959, and none of its attempted or successful Mars and Venus probes has appeared to be designed to land on the surface
- **Orbiting of optical telescopes**
- **Drawing of star maps** in different regions of the spectrum
- **Solar photography in X-rays**

Keldysh said the program was linked to the coming period of relative "quietness" in solar activity in 1964 and 1965. He said he expected global weather forecasting, intercontinental television and world-wide radio communications to be the practical fruits of the Soviet space program.

There is a possibility that the Cosmos satellites are multipurpose vehicles aimed at basic scientific exploration, at development of components for meteorological, communication, navigation, and even surveillance and warning satellites, and also functioning as testbeds for new materials, components and techniques for the manned space flight program.

Military implications of the Cosmos vehicles may be of some importance.

Top Russian officials, including Chairman Nikita Khrushchev, began to talk of "global rockets" last May 16, the day that the first Cosmos was launched. They claimed that Russia no longer needed to launch rockets over the North Pole to hit the U. S., and said that guarding the approaches from the North was no longer sufficient protection for this country. The U. S. has since revealed it would strengthen its early warning network coverage to the South.

Late last month, Soviet Marshall S. S. Biryuzov, commander of strategic rocket forces, claimed that rockets could be launched from satellites by ground command "at any desirable time and at any point of the satellite's trajectory." This kind of capability has been demonstrated by the launching of a Venus probe from an orbiting vehicle and more directly by the ground controlled return of Vostoks, the "spaceship satellite" test vehicles that preceded them, and by the return of several Cosmos satellites.

U. S. military planners have sponsored industry studies of the "bombs from orbit" technique but Defense Department has generally held the view that this is an unnecessarily expensive way to deliver a warhead, when a ballistic missile of sufficient range can put a warhead on any target on the globe probably with greater accuracy.

Physicist N. V. Pushkov, director of the Institute of Terrestrial Magnetism, the Ionosphere and Propagation of Radio Waves, said just after the launching of Cosmos 1 that the program for the series "includes both theoretical and practical problems." According to Moskovskaya Pravda Russia announced a number of areas of geophysical investigation assigned to the Cosmos vehicles that roughly resembled the goals of its intensive upper air rocket research program, conducted since 1949 but not publicized until 1956. Other references have indicated that living organisms may be among the Cosmos payloads.

Secrecy surrounding the missions and weights of the Cosmos satellites may have particular significance, or may be nothing more than retaliation for the secrecy imposed by the U. S. on the Discoverer, Midas and Samos launchings, beginning in the fall of 1961.

When the Cosmos launchings began just before the U. S. resumed nuclear testing in the Pacific after a hiatus of more than three years, there was speculation that the Cosmos satellites were intended to monitor the U. S. tests. Russia has said that Cosmos satellites were used to evaluate the potential hazard of the artificial radiation belt created last July 9 by a high-altitude U. S. nuclear explosion, but the Cosmos launchings continued through last December, long after U. S. atmospheric tests had ceased.

Cosmos launchings have been somewhat sporadic, even though the average from May 16, 1962, until late December was about one every three weeks. One firing was made in March, three in April, one late in May, one late in June, one late in July, one in mid-August, one late in September, two in October (16th and 20th) and one in December. Between the Oct. 16 and 20 shots, Russia conducted two test firings of so-called improved carrier rockets into the Pacific Ocean.

Of the first 12 Cosmos satellites launched 7 had orbits with inclinations to the equator of approximately 49 deg.—a departure from the standard Russian launch angle inclination of 65 deg.

In the first eight weeks of 1963, Russia had not launched another Cosmos, but it was not clear whether this signalled the end of the Cosmos series.

There was a break of more than eight weeks between the launchings of Cosmos 11 and 12.

In any case, the Cosmos launches—using satellites that are estimated to be as large or larger than Vostoks—indicate that it was a mistake to interpret the one-year gap in Soviet space launchings between Vostok 2 and the group flight of Vostoks 3 and 4 as a sign that the Russian program lacked the political and economic support of its early days.

The most accurate guess at the moment seems to be that the Cosmos vehicles are the same kind of second generation, multi-experiment observatory satellites that the National Aeronautics and Space Administration is developing but has not yet flown.

Official U. S. comment following the Nikolayev-Popovich flight last August tended to depreciate the achievement, saying that what the Russians did was nothing they could not have been expected to do eventually and nothing the U. S. could not do itself, given the time.

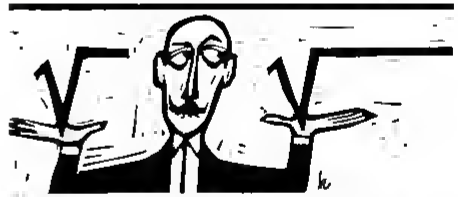
Nevertheless, if Russian claims are accepted, they programmed putting Vostok 4 into an orbit near that of

MANNED SPACE FLIGHT EXPERIENCE—U.S. & USSR

Pilot	No. Orbits	Flight Time
Shepard	0	0 hr. 15 min.*
Grissom	0	0 hr. 15 min.*
Glenn	3	4 hr. 56 min.
Carpenter	3	4 hr. 56 min.
Schirra	6	9 hr. 14 min.
Totals	12	19 hr. 06 min.
Gagarin	1	1 hr. 29 min.
Titov	17	25 hr. 18 min.
Nikolayev	64	94 hr. 22 min. +
Popovich	48	70 hr. 57 min. +
Totals	130	192 hr. 06 min.

*Suborbital ballistic flights
+Group flight—total orbits, 112, total flight time 165 hr. 19 min.

PROBLEMATICAL RECREATIONS 161



Which is larger, the tenth root of ten or the cube root of two?
—*Contributed*

More than 70,000 engineers and scientists are expected to attend this year's new IEEE International Convention, March 25-28 at New York's Coliseum and the Waldorf-Astoria Hotel. We hope to see many of our readers there. You'll find the Litton booths 1610-1618 and 1709-1717 on the first floor of the Coliseum. Drop by and see what some of our divisions are doing.

ANSWER TO LAST WEEK'S PROBLEM: The point values must be coprime, otherwise there are infinitely many impossible scores. The number of impossible scores is then ½ (x-1) (y-1) = 35. Hence x and y are (2,71), (3,36), (6,15), or (8,11). (3,36) and (6,15) are eliminated by the coprimality condition, and since a score of 58 could be obtained by making 29 two point free throws, the value of a free throw is 8 and that of a field goal is 11.

Vostok 3 with a 24 hr interval after launch of Vostok 3, they hoped to bring the spacecraft within 3 mi of each other initially and achieved a distance of somewhere between 4.03 and 4.1 mi. they launched each vehicle with a deviation from nominal launch time of less than 1 sec, and they conducted an excellent test of the tracking, computing and control system needed to bring two vehicles close together in space, whether manned or not.

The precision with which the orbits were matched can be seen from a comparison, based on corrected Soviet figures published some time after the flight, of the distances between periods apogees and perigees at various times.

When Vostok 4 joined Vostok 3 as Vostok 3 was on its 17th orbit, the periods of the two differed by only 7.8 sec. By the 49th orbit, this had grown to a difference of 8.4 sec. On the 17th orbit of Vostok 3, the difference in apogees was 4.21 mi. and in perigees 1.12 mi. Each increased gradually until the apogees differed by 6.26 mi. and the perigees by 2.05 mi. on the 64th orbit. No refined figures on the inclinations of the two orbits are available, but initial figures showed a difference of a few hundredths of a degree. Russia also said both Vostoks were launched from the same pad—indicating a total pad time for checkout and countdown of less than 24 hr. for Vostok 4.

Work program for the cosmonauts called for them to float free of their suspension systems on the fourth circuit and every second circuit of each subsequent 24 hr. Free-floating periods were to last for 50-60 min.

Russia said intership communication was good at all ranges up to the 1,767 mi that separated the ships just before they re-entered. The results of these tests "will make it possible to design still better equipment in the future ... for the next spaceships to go up and to have well organized communications with any number of ships in flight."

Soviet Lunar Flight

Washington—Soviet Russia is "far more thoroughly prepared" than the U.S. for a manned lunar landing and may send its first cosmonaut to the moon in 1965 or 1966, in the opinion of Dr. Boris Valnicek of the Czechoslovakian Academy of Sciences.

Dr. Valnicek quoted in a U.S. translation of a foreign technical journal, said he believes Russia already has the capabilities for a lunar landing insofar as the power of its rockets and space cabins go.

Space Activities Summary

Year	Success*	Wt. in Orbit (lb.)	Failure**
1957	Sputnik 1 (USSR)	8,000	Vanguard TV3
	Sputnik 2 (USSR)	8,000	
1958	Explorer 1	30.8	Vanguard TV3A
	Vanguard 1	56.25	Explorer 2
	Explorer 3	31	Vanguard TV5
	Sputnik 3 (USSR)	7,000	Vanguard SLV1
	Explorer 4	38.4	Vanguard SLV2
	Pioneer 1 (probe)	84.4	USAF Lunar Probe
	Pioneer 2 (probe)	87.3	Explorer 5
	Pioneer 3 (probe)	12.95	Vanguard SLV3
	Score	8,750	Beacon
1959	Lunik 1 (probe) (USSR)	3,245	Vanguard SLV5
	Vanguard 2	21.5	Discoverer 3
	Discoverer 1	1,300	Vanguard SLV6
	Pioneer 4 (probe)	13.4	Discoverer 4
	Discoverer 2	1,600	Explorer
	Explorer 6	142	Beacon
	Discoverer 5	1,700	Transit 1A
	Discoverer 6	1,700	Pioneer
	Lunik 2 (probe) (USSR)	858.4	
	Vanguard 3	100	
	Lunik 3 (USSR)	4,037	
	Explorer 7	91.5	
	Discoverer 7	1,700	
	Discoverer 8	1,700	
1960	Pioneer 5 (probe)	94.8	Discoverer 9
	Tiros 1	270	Discoverer 10
	Transit 1B	265	Midas 1
	Discoverer 11	1,700	Explorer
	Spaceship 1 (USSR)	10,008	Echo
	Midas 2	5,000	Discoverer 12
	Transit 2A (and Greb)	265	Courier 1A
	Discoverer 13	1,700	Pioneer (probe)
	Echo 1	240	Somos 1
	Discoverer 14	1,700	Discoverer 16
	Spaceship 2 (USSR)	10,120	Explorer
	Discoverer 15	1,700	Transit 3A/Greb
	Courier 1B	500	Pioneer
	Explorer 8	90.14	Mars Probe (USSR)
	Discoverer 17	2,100	Mars Probe (USSR)
	Tiros 2	280	
	Discoverer 18	2,100	
	Spaceship 3 (USSR)	10,060	
	Discoverer 19	2,100	
1961	Somos 2	4,100	Venus Probe (USSR)
	Explorer 9	80	Explorer S45-1
	Heavy satellite (USSR)	14,292	Discoverer 22
	Venus Rocket (USSR)	1,419	Mercury Atlas-3
	Discoverer 20	2,450	Explorer S45-2
	Discoverer 21	2,200	Discoverer 24
	Spaceship 4 (USSR)	10,340	Explorer S55
	Transit 4B/Ioffi	307	Discoverer 27
	Explorer 10	79	Discoverer 28
	Discoverer 23	2,100	Somos 3
	Explorer 11	82	Mercury Scout 1
	Spaceship 5 (USSR)	10,330	Discoverer 33
	Vostok 1 (USSR)	10,418	
	Discoverer 25	2,100	
	Transit 4A/Injun/Greb	270	
	Discoverer 26	2,100	
	Tiros 3	285	
	Midas 3	3,500	
	Vostok 2 (USSR)	10,430	
	Ranger 1	675	
	Explorer 12	83	
	Explorer 13	187	
	Discoverer 29	2,100	
	Mercury Atlas-4	2,700	
	Discoverer 30	2,100	
	Discoverer 31	2,100	
	Discoverer 32	2,100	
	P-21 (probe)	94	
	Midas 4	3,500	
	Discoverer 34	2,100	
	Ranger 2	675	
	Discoverer 35	2,100	
	Transit 4B TRAAC	400	
	Discoverer 36/Oscar	2,110	
1962	Ranger 3	727	Discoverer 37
	Tiros 4	285	Composite 1 (5 payloads)
	Mercury Atlas-6	2,987	Blue Scout (USAF Satellite)
	Delta 1 (USAF)		Blue Scout (USAF Satellite)
	Discoverer 38	2,100	ANNA 1A
	OSO-1	458	Blue Scout (USAF Satellite)
	Eta 1 (USAF)		Mariner 1
	Cosmos 1 (USSR)		Venus Probe (USSR)
	P-21A (probe)	94	Venus Probe (USSR)
	Cosmos 2 (USSR)		Venus Probe (USSR)
	Kappa 1 (USAF)		Atlas Agena (USAF) Satellite)
	Lambda 1 (USAF)		
	Ranger 4	730	
	Cosmos 3 (USSR)		
	Ariel 1	132	
	Cosmos 4		
	Pi 1 (USAF)		
	Rho 1 (USAF)		
	Sigma 1 (USAF)		
	Mercury Atlas-7	2,975	
	Cosmos 5 (USSR)		
	Phi 1 (USAF)		
	Blue Scout (USAF probe)		
	Chi 1/Oscar 2 (USAF)		
	Psi 1 (USAF)		
	Omega 1 (USAF)		
	Tiros 5	284	
	Alpha Beta 1 (USAF)		
	Alpha Gamma 1 (USAF)		
	Cosmos 6 (USSR)		
	Alpha Zeta 1 (USAF)		
	Alpha Eta 1 (USAF)		
	Blue Scout (USAF probe)		
	Alpha Theta 1 (USAF)		
	Cosmos 7		
	Alpha Kappa 1 (USAF)		
	Alpha Iambda 1 (USAF)		
	Vostok 3 (USSR)	10,160	
	Vostok 4 (USSR)	10,160	
	Cosmos 8 (USSR)		
	Alpha Omicron 1 (USAF)		
	Mariner 2 (probe)	447	
	Alpha Sigma 1 (USAF)		
	Alpha Upsilon 1 (USAF)		
	Alpha Chi 1 (USAF)		

Success	Weight in Orbit (lb.)
Tiros 6	281
Cosmos 9 (USSR)	
Alouette	320
Beta Beta 1 (USAF)	
Explorer 14	89
Mercury Atlas 8	3,000
Beta Epsilon 1 (USAF)	
Cosmos 10 (USSR)	
Ranger 5	755
Cosmos 11	
Beta Kappa 1 (USAF)	
Explorer 15	98
Anna 1B	355
Mars 1 (USSR probe)	1,965
Beta Omicron 1 (USAF)	
Beta Pi 1 (USAF)	
Blue Scout (USAF probe)	
Beta Rho 1 (USAF)	
Beta Sigma 1 (USAF)	
Beta Tau/Injun 3 and 3 Piggybacks (USAF)	
Relay 1	172
Beta Phi 1 (USAF)	
Explorer 16	222
Blue Scout (USAF probe)	
Transit 5A	135
TRS 1	1
Cosmos 12	

Sources: National Aeronautics and Space Council; Goddard Space Flight Center; North American Air Defense Command; Smithsonian Astrophysical Observatory; Congressional Record

* Successes include successful ejection into orbit without regard to payload operation.

** USSR does not announce failures.

Note: USAF has not identified its satellites since the launch of Discoverer 38 Feb. 27, 1962.

Missiles

Missile N-12 of the Martin Titan 2 test series is launched at Cape Canaveral

LOCKHEED/NAVY POLARIS A3 08, first long range version of the submarine launched ballistic missile to make a fully successful down-range flight, is shown on its transporter-erector prior to the flight at Cape Canaveral.

New Missile Concepts Stress Environment

By Irving Stone

Los Angeles—Planning, development, deployment and updating of U.S. ballistic missiles has reached a new plateau of technological effort that ranges from formulation of future strategic concepts to refinements for greater effectiveness of missile systems on alert status.

Much future design of missiles will depend on the environment that will be most desirable for increasing the potential of advanced systems.

Ballistic missile efforts by the U S now include

- **Advanced ICBM** planning, with emphasis on survivability
- **Midrange ballistic missile**, with mobility for high survivability
- **Initiation** of large-scale hardened deployment of the Minuteman ICBM and projected improvements for future wings
- **Improvement-modification** of Atlas and Titan ICBM systems, for greater reliability.
- **Range** increases for the Polaris fleet ballistic missile.

Concepts for next-generation U S. intercontinental ballistic missiles will be based on offsetting accuracy and high-yield payloads of hostile ICBMs. Basic premise is that the most effective deployment for retaliation against a combination of pinpoint targeting and large warheads lies in novel basing schemes.

Two general approaches appear feasible—mobility and concealment. Mobility could encompass land or water deployment. True concealment would involve methods not previously used, ruling out deployment in fixed, underground, conventional silos on the theory that no fixed, hardened site is immune to a warhead incorporating accuracy and high yield.

A next-generation ICBM, implemented with a year of study followed by four years of development, would attain operational readiness in 1968. Urgency could cut development time to less than three years, for deployment in late 1966 or early 1967. If the system were complex, five years for development would be required, providing deployment in 1969.

Investigation of new modes of survivability are contained in studies already initiated by USAF's Ballistic Systems Division (AW Nov. 5, 1962, p. 103). These studies are broad investigations intended to cover the entire parametric range of missiles with weights from 30,000 lb. to 500,000 lb. Reason for the inclusion of the "small" missile is to consider all forms of mobility. The mobile midrange ballistic missile now in the program definition phase at Ballistic Systems Division is considered a forerunner of the new systems.

The advanced studies cover three package efforts: guidance technology, command and control, and a third encompassing six areas—encapsulation, deployment techniques, small missile, long-range ICBM, large payload, and positive early warning.

Top emphasis will be placed on guidance, since accuracy is considered the key in the delivery capability of every ballistic weapon. In parallel efforts, global ranging guidance will be studied by American Bosch Arma and IBM, encapsulated missile guidance by AC Spark Plug and Sperry Rand, and radio inertial guidance by IBM and General Electric. Command and control will be analyzed by RCA, large payloads by Space Technology Laboratories and Martin, encapsulation techniques—advanced packaging—by General Dynam-

ics/Astronautics and Lockheed Missiles and Space Co., and use of early warning by North American Aviation's Space and Information Systems Division and Hughes Aircraft. United Aircraft and STL are studying the small missile, and Boeing and McDonnell Aircraft the large.

All studies should be complete by end of the year and are funded for $150,000 to $200,000, except for guidance and command and control studies, which may cost more because of breadboard work.

Concept of encapsulation is to achieve long-time dormant deployment underwater, or perhaps underground, and is applicable to a missile of any size.

More latitude exists for underwater deployment than with a land site.

Cost of encapsulation, basically involving use of a hard, hermetically sealed shell to preserve a suitable environment for the missile, is conceived as costing no more than the above-surface gantry, below-surface coffin, or silo emplacements for existing missile systems.

An encapsulated dormant missile deployed under water promotes survivability primarily through concealment. Water is an effective neutron absorber also and ensures high survivability except against a very close blast. Both moored and floating configurations are envisioned, with mooring release accomplished by sonar signal or signal from rocket or aircraft.

Underwater deployment in arctic wastes is being considered but doesn't appear as attractive as inland waters, where encapsulated submerged missiles would not be subject to hostile underwater-sensing techniques. Arctic deployment would make inspection and replacement procedures difficult and personnel involved would spend much time protecting themselves against the harsh environment.

Power-carrying devices used for the missile would develop temperatures easily discernible against the background temperature of the water. Movement of any natural reference body, such as a huge mass of ice, would make difficult the location of an encapsulated missile for inspection to determine that it had not been sabotaged.

Release of the cocooned missile from its anchorage could be achieved by dumping water ballast to pop the missile above the surface for ignition. Another scheme would be to employ a cold boost, similar to the Polaris technique, to blast the missile into the air for ignition.

Water mobility could be attained with the encapsulated missile on a barge which could be sunk automatically if intelligence indicated that an attack impended. Launch from the sunken barge could be achieved with missile pop-up as in any other underwater deployment scheme.

Communication with an encapsulated, dormant, underwater missile will require intensive study. A land-based, hermetically sealed missile could use camouflaged antenna systems protruding above ground or, for greater survivability, a buried transmitter-receiver system utilizing radio waves for command.

Defense Department's decision to proceed with the development phase of USAF's mobile mid-range ballistic missile is expected to be made this spring or at latest by early summer. Now in its program definition phase, the MMRBM program would provide the first weapon system designed for land and sea mobility, which translates strategically into increased survivability and thus offers the economic and operational advantages of requiring fewer weapons for an effective force.

DOD's decision is expected to be based primarily on the projection for this decade of the political situation in Europe, where the weapon would be deployed for NATO. Deployment is also possible with U.S. forces in other parts of the world. Solution of the problem of nuclear warhead control would be another factor in DOD's decision.

Deployment for launch at sea from several types of vessels would be a straightforward task. Prime limiting factor for land use would be ability of roads and bridges to accommodate the weight and turning radius of the missile hauler, a truck-trailer combination designated as transporter-launcher.

Development of the MMRBM involves no make-or-break problem areas. Design would be aimed toward relative simplicity and so would the production task. A two-stage unit, the missile will be about 23 ft. long and weigh approximately 11,000 lb. with re-entry system. First stage is not expected to exceed a diameter of 4 ft. 8 in. Controlled range will be 200-2,000 naut. mi.

Guidance and command and control systems probably will offer the greatest problem areas. Reaction time while the transporter-launcher is mobile probably will be 5-15 min. Circular error probability (CEP) is not likely to be less than 1,000 ft. at a range of 1,000 naut. mi. Command and control network will have to embody survivability characteristics at least equal to those of the missile, incorporate anti-jamming, and resist effects of nuclear blasts.

The transporter-launcher, initially viewed as one of the more difficult problems, probably will emerge as one of the simplest. It will be configured to use a standard trailer, hauled by a standard motor truck-tractor unit, as the launcher. Buttoned-up, the trailer probably would be indistinguishable from any large, conventional trailer.

A pair of doors at the rear would allow the missile in its container to slide into the trailer on rails at the same level as the rails on the shipping stand backed against the trailer. A gear arrangement in the trailer could erect the container to a vertical position through a pair of doors forming the roof and opening outward from the center. In this vertical position, the missile could be popped from its container by a compressed air blast, then ignited in the air, like the Polaris. Another launch mode could involve light-off directly from the truck, with a bottom portion of the truck dropped to the pavement as a blast plate.

Forward portion of the trailer could be walled off from the missile-carrying part to provide berths for personnel and room for avionic gear.

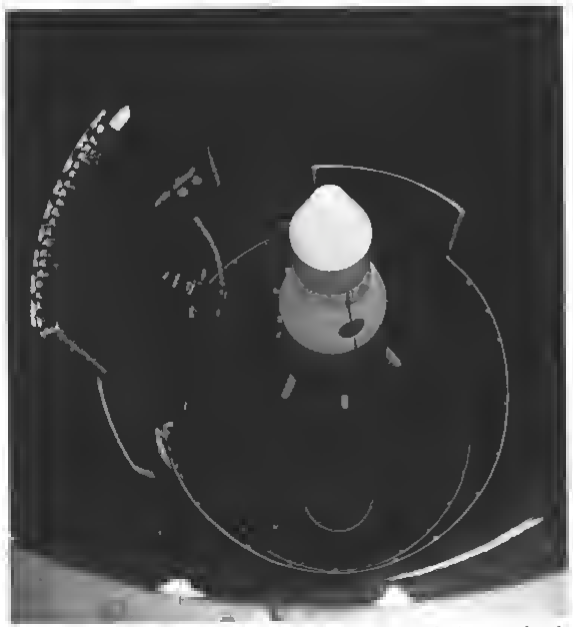
Deployment of MMRBM systems probably would be in squadrons of up to 30 vehicles. While sabotage of one transporter-launcher might not be difficult, sabotage of a substantial part of a roving squadron is considered to be improbable.

Configuration of the weapon system will be established during the program definition phase. Contractors conducting this phase include Hughes Aircraft for integration, assembly, and checkout; Thiokol for propulsion; Ford Motor Co.'s Aeronutronic Division for the re-entry system; General Precision Equipment for guidance; Goodyear Aircraft, transporter-launcher; Martin-Sylvania and Hughes Ground Support Group, command and control; and Bechtel Corp., architect-engineer. One of the command and control contractors will be eliminated after the program definition phase.

In the area of operational missiles, significant refinements are under way and planned for the Minuteman ICBM to bolster the reliance that Defense Dept. has placed on it as the country's principal strategic weapon system.

A sixth wing now being added to the Minuteman inventory seems a logical place for the introduction of a substantial block of improvements since these might require at least two years for development and test.

Meanwhile there would be a backstop build-up to a total of 800 emplacements in the first five wings: Malmstrom AFB, Mont., with 150; Ellsworth AFB, S. Dak., 150; Minot AFB, N. Dak., 150; Whiteman AFB, Mo., 150; and Warren AFB, Wyo., 200. These are in various degrees of site completion. Indications are that production and force build-up will be fast, with total deployment of the 800 missiles in the first five



UNUSUAL VIEW shows Minuteman inside its silo at Cape Canaveral prior to test launch.

DOD Emphasizes Nike-X Anti-Missile

Washington—Five years of concerted effort and expense have produced no pat solutions to effective defense against a mass intercontinental ballistic missile attack, but the Department of Defense is beginning to devote serious effort to a relatively low-altitude interception system known as Nike X.

Despite the system's many problems, DOD has decided to go ahead with development (AW Feb. 11, p. 36), and most of the $450 million requested for Fiscal 1964 for ICBM defense is likely to go for Nike X rather than Nike Zeus. The latter is designed to intercept targets at 70-100 mi. altitude; Nike X would intercept at 20-30 mi.

A related concept to Nike X is that of Sprint, which would be a low-altitude interception system complementary to Nike Zeus. Feasibility studies for Sprint, an extremely high acceleration missile, but smaller, lighter and less expensive than Nike Zeus, are sponsored by the Army at Douglas Aircraft Co., Martin-Orlando, and North American-Columbus.

Problem Gets Tougher

In one sense, the offense has made considerably more progress than the defense during the last five years. The successful development of the Polaris missile and its nuclear submarine launcher has greatly increased the complexity of the ICBM defense problem since the Soviet Union can be expected to match the U.S. Navy's capability.

Because an effective ICBM defense appears no closer than it did five years ago does not mean that the interval has been wasted. Defense Department and industry scientists are vastly more knowledgeable about the problem and its inherent difficulties than they were five years ago. There is much more knowledge about the radiation and trajectory signature of an ICBM warhead during re-entry as a result of the Advanced Research Projects Agency's Project Defender measurements program. But there still is much to learn on the subject.

The ARPA program and Nike Zeus tests in the Pacific have led Defense Department officials to conclude that the best known technique for discriminating between warheads and decoys is by the difference in their trajectories as they re-enter the atmosphere. But this atmospheric filtering does not become pronounced until the targets have penetrated to altitudes of less than 50 mi. At these low altitudes, a thermonuclear warhead is only 15 sec. or less from its impact point or from detonation.

This poses a hard choice: if a Nike-Zeus type system is used to intercept targets at altitudes of about 70 mi., then it is impossible to identify positively warheads and decoys and thus sufficient expensive anti-ICBM missiles to destroy nearly every object are required. This makes it relatively easy for an enemy with large boosters to release great numbers of low-cost decoys to exhaust the fire of the defensive system, then follow up with thermonuclear warheads.

Singling Out Warheads

The other possibility is to build a low-altitude anti-ICBM defense system which uses less costly missiles and rely upon atmospheric filtering to identify the actual warheads that must be destroyed. But this imposes a rigorous challenge for the anti-ICBM missiles which must be launched, reach intercept altitude and kill the warheads in a matter of 10-15 sec. at most. Additionally, the low-altitude system must use hardened missile launchers and radars which are relatively invulnerable to blast and fall-out produced by the small nuclear warheads of the interceptor missiles or from the large thermonuclear warhead if it detonates during the process of interception.

Proposals for an orbital ICBM defense system using swarms of satellites armed with missiles which might be able to intercept enemy ICBMs during the mid-course of their trajectory have been proposed and studied under the Project Bambi program. But the vast expense of such a system and its vulnerability to enemy counter measures has produced little enthusiasm for the concept in the Pentagon. This attitude has been strengthened by reliability problems experienced by other military satellites such as Midas and the Satellite Inspector, which are far less complex than would be required for ICBM defense.

Remarkable progress in the field of optical masers (lasers) in the past two years has prompted speculation and interest in their possible use as a defense against ICBM warheads. If lasers capable of developing extremely high power levels can be devised, this could be the sorely needed defense against ICBMs, but the consensus is that this prospect is at least five to 10 years away.

Longer Range Is Goal of Polaris B3

Plan to stretch substantially the range/payload capability of the Navy's 2,500 naut. mi. Polaris A3 fleet ballistic missile is under way with a feasibility study at the Lockheed Missile and Space Co. for a follow-on version of the weapon, designated B3.

Prime refinement would be an increase in diameter for a significantly larger propellant grain. This would hold the missile's length to its present dimension, 31 ft., to keep modification of existing nuclear-powered submarines to a minimum—retaining their keel depth, but increasing the diameter of the launch tubes. Retention of the same number of tubes, two parallel rows of eight, could be provided by increasing the length of the missile compartment, or fewer launch tubes could be installed in the existing space.

Grain web thickness might be increased 10-12 in., resulting in a diameter of 75-80 in. compared with the 54-in. Polaris A3.

Applied to both first and second stages, this increase in grain volume would give Polaris a new strategic capability. To the vital characteristic of survivability through underwater mobility, it would add a new targeting range approaching the capability of an intercontinental ballistic missile. Alternatively, a higher yield warhead could be delivered over the same range as the A3. A combination of increased range and payload also would be possible.

Earliest a Polaris B3 could be introduced into Navy inventory is late 1965, allowing for a normal research, development, test, and production program and using substantially similar propellant formulations to the A3. For the Aerojet first stage, this is a Class 2 oondetonable polyurethane type, and includes a nitroplasticizer for added energy, curing at ambient temperature, and avoidance of grain shrinkage. For the Hercules Powder second stage, a Class 9 detonable double-base propellant is used.

Polaris B3 may take advantage of interim developments of solid propellants using light-metal additives like lithium hydride for a big jump in specific impulse. Such a technique has become a field of increasing interest for military planners, who see in it a means of achieving a specific impulse well above 300 sec., a significant advance from the 245 value commonly used for first stage applications.

Polaris A3X, now in the development test phase, is designed to increase range 1,000 naut. mi. over the A2. It uses a first-stage propellant flame temperature exceeding 5,000F. Development of this propellant system posed difficult problems, solution of which were critical for attaining the missile's advance in operational capability.

First stage of the A3, the largest glass filament-wound case to be used in a flight program, incorporates rotating nozzles for thrust vector control. This design was selected because it is the shortest of the movable nozzle systems and best fitted for Polaris, which is a volume-limited system.

Second stage of the Polaris A3 also uses a glass fiber case, but freon injection provides thrust vector control.

The development test program, which has involved pad-launches of less than a dozen missiles so far, has resulted in a number of failures, attributed to random difficulties.

wings with Strategic Air Command completed by 1965.

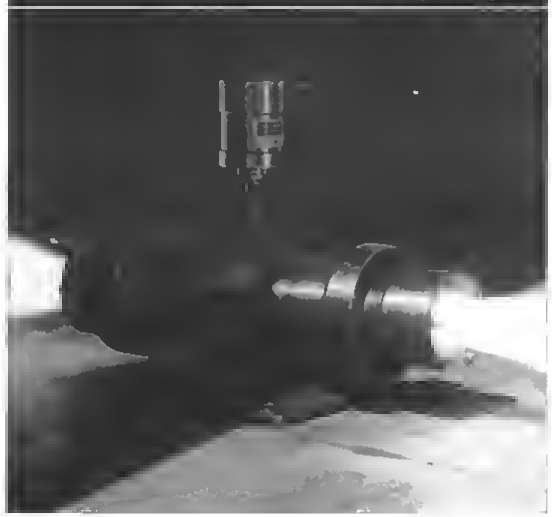
Minuteman's plan and authorization program provides for emplacements subsequent to Wing 6, and the assumption is that additional refinements will be incorporated up to a late cut-off point.

Improvements in process

● **Guidance accuracy.** Greatest effectiveness against targets is possible through improvement here. Increase in accuracy even in tenths of miles offers more substantial results than relatively large increases in warhead yield. Minuteman achieved the CEP initially programmed for it and this basic accuracy was improved after relatively few missiles had been fired. Further reduction of CEP involves refinement of the components—gyros, velocity-measuring devices, and mounting platform.

■ **Range/payload capability.** Weight saving is another aim of the guidance refinement program, for translation into greater range or payload capacity. Greatest weight-saving probably stems from modification of the second stage (AW Sept. 3, p. 68). For use in Wing 2 at Ellsworth AFB, this stage will be built of titanium alloy instead of steel to save 218 lb. Second stage diameter has been increased for a greater propellant charge for more range or payload. Third stage, incorporating a glass filament-wound case, already is at its practical limit of lightness. Weight is not a critical factor in first stage and its steel case probably will be retained.

■ **Radio launch control.** Development work is being conducted for triggering Minuteman missiles by radio signal. Initially revealed in Aviation Week & Space Technology (May 18, 1959, p. 26), this operational technique would involve radio transmission between the buried launch control center and the



silo. This system, which would replace the costly, complex, and relatively vulnerable cable network now used, originally was considered for introduction with the fourth squadron at Ellsworth, but probability is that it will be introduced in a later Minuteman deployment. Considerable development will be involved in attaining a proper balance of radio launch control effectiveness and system invulnerability, which lies, in addition to the unwired installation, in virtually jam proof transmission. Radio waves for the system would be broadcast on a wide range of frequencies and decoded at the receiving end. Initial estimates were that radio launch control would save approximately $300,000 per missile installation compared with the existing cable system that involves hundreds of miles of underground redundant lines to the launch control centers to missiles. Cost of installing cable is $20,000-$35,000 per mile.

• **Propulsion.** Minuteman program managers maintain a close relationship with Polaris and large solid rocket developments. Improvements stemming from these programs will be cranked into the Minuteman program if production schedules and deployment timetables permit.

• **Site construction.** Early in the Minuteman program, construction people felt there would be little improvement in the learning curve, but cost of successive deployments has decreased progressively. A new technique, integrated by Morrison-Knudsen, construction contractor for Wing 5 at Warren AFB, is considered a distinct step forward in construction mass production and may sharpen competition on work at future Minuteman sites. The company drills the silo holes instead of

Large Solid Future

Analysts at USAF's Ballistic Systems Division and its technical adviser, Aerospace Corp., are considering the potential of 120-in. and 156-in. diameter solid-propellant rocket motors either as strap-on units or clusters for lofting heavy warheads or space weapon systems.

This projection further obscures the thin line which separates the conventional intercontinental ballistic missile from the workhorse function of the large solid propellant booster.

The 120-in. motor, under development at United Aircraft's United Technology Center, is the first of the huge solids to find application for a specific vehicle, the Titan 3C. Feasibility demonstrations of the 156-in. and 260-in. motors, for which a competition is under way, will lay the foundation for an expansion of huge solid motor utility for military mission applications if these are generated for the 1970-80 decade.

TITAN I is launched after elevation from operational training silo at Vandenberg

blasting and tediously excavating the rubble and earth with a clamshell bucket.

An extensive program to increase performance, reliability and safety in Atlas E and F has been initiated as a package effort involving about 250 items for each and covering missile, site and aerospace ground equipment. This effort is being carried on against a background of maintaining complete operational status for all Atlas versions—D, E, and F—subject to downtime occasioned by the updating work.

Site activation for the silo-deployed Atlas F was completed last December, 21 days ahead of schedule. Atlas E underground coffin site activation was completed 40 days ahead of schedule in November, 1961. Atlas D previously had been completely activated, and refinements dictated by the Golden Ram program incorporated (AW May 12, 1962, p. 137).

Category 2 testing, concerned with marriage of the missile to its operational environment, is being completed for both Atlas E and F at Vandenberg AFB, Calif., and involves contractor and SAC personnel using operational checkout and launch gear. Category 3 testing, completely conducted by Strategic Air Command for operational training, will be instituted as soon as the Category 2 program is completed.

Preliminary steps in Atlas E updating were begun in October 1962, with guidance changes to provide greater accuracy and better maintainability. Atlas F guidance changes were begun a month later in a program practically identical to that for Atlas E, since the missiles are essentially the same. Considered urgent, the guidance changes have been conducted by the contractor, Arma, on a step basis from site-to-site and from base-to-base so that the Atlas force could remain essentially on emergency war order (EWO) status.

The formal updating program for Atlas E, exclusive of guidance changes previously begun, was started in January and will be completed in July, 1964. It is a joint effort of SAC for missile changes and Logistics Command for coffin changes, with special assistance from contractors. It also is being conducted as a step program. The package aspect, which lumps the various items involved, will minimize down time, so that maximum emergency war order status can be maintained.

Bases involved are Warren, Forbes AFB, Kan., and Fairchild AFB, Wash., which will participate successively, each with one squadron of nine missiles plus a tenth, housed in a missile assistance maintenance structure (MAMS), which can be used as a substitute missile.

Updating schedule for the F is being planned now. The program is expected to start in July and will extend 20 to 24

AIR FORCE crews launch Atlas 57F from hardened site at Vandenberg AFB, Calif.

months, depending on the number of missiles which can be removed from emergency war order status with SAC's permission.

Because there are six bases, each with one squadron of 12 missiles deployed in hardened silos, the Atlas F program will involve a larger effort. Each squadron has a 13th missile housed in a maintenance structure. Atlas F updating also is expected to be a SAC Logistics Command joint effort.

Changes will be tested in Atlas E and F facilities at Vandenberg AFB, and the intention is to launch two missiles each in the fully modified E and F configurations. Launches of Atlas E should be completed by June, and F by November.

Atlas E and F Category 3 test programs are being analyzed at the request of Defense Department to determine how much they could be accelerated for an earlier determination of Atlas force total effectiveness under the Single Integrated Operational Plan (SIOP) for the weapon system. This determination will be based on an assessment of operational readiness, reliability, range, CEP and other critical factors.

Acceleration would include speed up of the package installation at Vandenberg Operational Suitability Test Facility One (OSTF 1) and 576C SAC training below-ground coffin installations for Atlas E, and OSTF-2 and 576D and E for Atlas F.

A "buy-out" analysis of Atlas production requirements through 1966 is being made to determine how many missiles will be required for advanced ballistic missile re-entry system (ABRES) testing and combat training launches. This is an economy measure for producing and storing the needed missiles, instead of maintaining a production line for the relatively few missiles that would be required.

Production line for the Titan 2 ICBM is feeding missiles to operational sites as fast as they can be accepted. Davis-Monthan AFB at Tucson, Ariz., received its first operational type missile in December, and McConnell AFB, Wichita, Kan., received its first unit in January. Little Rock AFB, Ark., the final Titan 2 deployment site, will receive a missile next. Total deployment at these three bases will involve only 54 missiles—two 9 missile squadrons at each base. All three bases are to be operational this year.

Site activation improvements have been fed into Titan 2 bases as a result of knowledge gleaned from this exacting task with Titan 1. A product-improvement program for Titan 2 will be based on changes dictated by SAC experience with the missile in Category 3 testing.

A major milestone in the Titan 2 program was passed when the missile was captive-fired successfully in January in an operationally configured training facility at Vandenberg. Only the first stage was loaded—the second stage was water ballasted for realistic weight—and the engines were cut before all first-stage fuel was burned. But the test exceeded the time that it would have taken the missile to clear the silo in a free launch.

This was the first test of Titan 2 in its true environment and showed that design of the missile and facility were compatible. Silo ducts were adequate to bleed the exhaust to the surface and only minor damage resulted to the flame bucket, demonstrating that the silo was reusable. Launch phase of the first Titan 2 shot from the silo last month also was a success, but the missile exploded at an altitude of about 3 mi. It was the first Category 1 flight from an operationally configured training facility.

All Titan 1 missiles have been deployed in silos since September, 1962, but there is a trickle of production to supply missiles for SAC training launches. Deployment now totals 53 missiles at five bases.

Each base except Lowry AFB, Colo., has one squadron of nine Titan 1 missiles. Lowry has two squadrons. A silo destroyed at Beale AFB, Calif., when a missile exploded in May, 1962, is being repaired and will receive a Titan 1 to bring the deployed force to a total of 54. In addition, there are three Titan 1 silos at Vandenberg AFB, which essentially are operationally configured, but not hardened to the extent of an operational site.

The silo elevator had been a major problem. One OSTF at Vandenberg was destroyed in December, 1960, when a Titan 1 test missile was brought to the surface on the elevator, which then gradually dropped back into the silo, hitting the bottom at faster than design speed. The missile ruptured, then exploded. To ensure against repetition, fail-safe devices have been built into the Titan 1 launcher system, so that even if power and brakes fail a governor will prevent the elevator from bottoming at more than design speed. There have been thousands of test runs, lifting the missile to the surface and descending to silo bottom, without any critical occurrence. Minor problems have been encountered, but these have been remedied.

Numerous changes could have been incorporated in the Titan 1 system, but this would have involved delay and considerable expenditure, and Titan 1 was a priority program with a relatively high degree of design freeze. Hence, changes were held to a minimum, with major items reserved for Titan 2.

There is an updating program, concerned mainly with changes for higher reliability, based on SAC's usage experience and problems encountered in Category 2 R&D tests.

For USAF Titan III:
A Boost
of over 2,000,000 lbs.

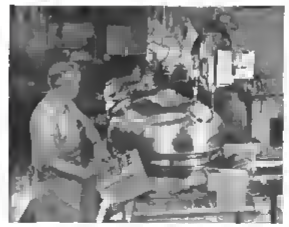
When the U. S. Air Force's Titan III thrusts toward space, its boost will come from two giant solid-propellant rockets. Together they will produce a push of better than two million pounds. For these huge twins, the Wright Aeronautical Division of Curtiss-Wright is fabricating solid-propellant motor cases ten feet in diameter and seventy-five feet tall—among the largest ever made. The contract for this project, awarded to Curtiss-Wright by the United Technology Center, a division of United Aircraft Corporation, highlights a space age capability at the Wright Aeronautical Division that has set "down-to-earth" records, too: 100% on schedule for the hundreds of motor cases already produced for the Minuteman and Pershing missiles.

In still other space age areas, Wright Aeronautical is developing main propulsion systems and vernier control systems for space applications, including subminiaturized attitude control devices; and developing advanced materials to withstand the ultra-hot blasts of future ultra-big boosters.

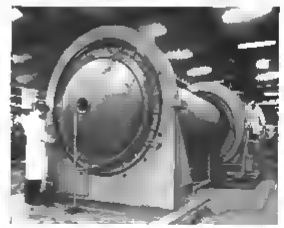
These programs are as striking for their overall diversity as for their individual significance. Quite obviously, they require technological abilities of great depth and breadth in metallurgy and heat transfer, propulsion and subminiaturization. This unusually comprehensive combination of capacities at Wright Aeronautical is available for *your* space age programs, too.

Information is available on request.

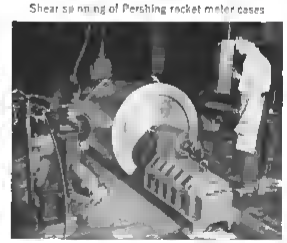
3 dimensional machining Pershing missile domes



Machining the [illegible] diam. Minuteman case



Shear spinning of Pershing rocket motor cases

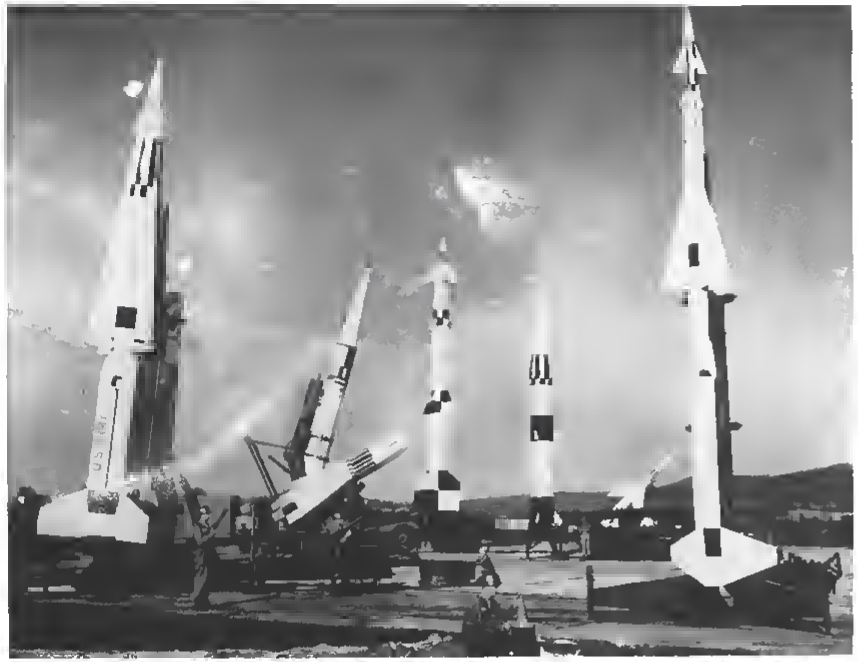


Wright Aeronautical Division

CURTISS-WRIGHT CORPORATION

Main and Passaic Streets — Wood-Ridge, New Jersey

Circle Number 153 on Reader-Service Card



ARMY MISSILE INVENTORY includes (left to right) Nike Hercules anti-aircraft missile, Hawk low altitude anti-aircraft missile battery; Sergeant artillery missile; Nike Zeus anti-ICBM missile; Pershing artillery missile; Lacrosse field missile, and Nike Ajax. Hand held rocket launchers are carried by soldiers in left foreground and the Entac anti-tank missile is in carton in right foreground.

Multipurpose Field Missiles Are Sought

By George Alexander

Huntsville, Ala.—Design of battlefield missiles, which has tended toward development of many diverse, highly specialized systems, is undergoing a gradual shift toward a modular concept.

U.S. Army's future procurement of missile systems—and the Army is the principal customer for field use missiles—will be based on the criteria of versatility, modularity and simplicity approaching that of artillery shells.

Lt. Col. James Miller, director of the Future Missiles Systems Division in the Army Missile Command's Directorate of Research and Development, said that any new missile system must be able to do the job of two or more weapons presently in the hands of troops. He cited the Ling-Temco-Vought Lance, which will replace the Lacrosse and Honest John rockets, as the first step toward greater versatility. Systems with highly-specialized missions are not likely to find favor with the Army, he said, because of cost and complexity.

Modularized systems, with components that could be easily and rapidly assembled to make a weapon adequate for a different task, will be emphasized. Such a concept might be applied to a complete weapon system, individual units of which could be put together to form a larger or more potent weapon. Assembly of larger weapons from smaller units is a more probable technique than pulling individual pieces of hardware off a large missile.

Simplicity—of operational use, training, parts and maintenance—is being stressed repeatedly by Army officers here. Maj. Gen. Francis J. McMorrow, commander of the Army Missile Command, recently told a meeting of the American Ordnance Assn. that the Army is seeking in missile systems a "wooden round," an artilleryman's term designating a unit which can be built simply, stored for extended periods of time, handled roughly and which is adaptable to climatic extremes.

"When you need it," Gen. McMorrow said, "it's ready. Put it on the launcher and it fires. If it doesn't, set it aside and shoot the next one."

Concept of a wooden round entails low unit costs and high reliability and he invited industry to provide ideas.

Self-contained propulsion systems will be required by the Army in future missile systems. Pre-packaged liquid propellant engines, which will power the Lance missile, will be acceptable as well as solid propellant motors, Col. Miller said. Other Army interests:

- **Missile guidance system** using a laser.
- **Aircraft and helicopter** mounted missile systems.
- **Missile with indirect fire** capability, which would be zeroed in on soft targets by forward observers.

DOD's insistence on program definition prior to initiation of development of any new missile system will be a fact of life, Army officials here say. Exhaustive in-house studies, perhaps with some industry participation, will define sharply just what the Army wants in a new system.

At least 8-10 years operational use from any new system will be sought by the Army. Desired lead-time in the development of a new system, from start of development to first production units, will generally be four years or less. Replacement of one generation of missiles by another will be done on an individual systems basis, rather than a complete simultaneous overhaul of the inventory. Army currently is looking at its requirements 20 years from now for planning purposes.

Battlefield missiles soon to phase into service:

- **Pershing**, a two-stage solid propellant missile with a range of 100-400 mi. Inertially-guided and fired off its own air-transportable transport/launcher, the 35 ft. long, 3.5 ft. diameter missile is being built by Martin-Orlando. Now in production, it will be in the hands of troops in the field shortly. About a half-dozen research and development Pershings remain to be fired from Cape Canaveral, Fla.
- **Sergeant**, a two-stage solid propellant field missile with range up to 75 mi. The 34 ft. long inertially guided missile, built by Sperry-Utah, is in production and soon will be issued to troops.

In advanced development:

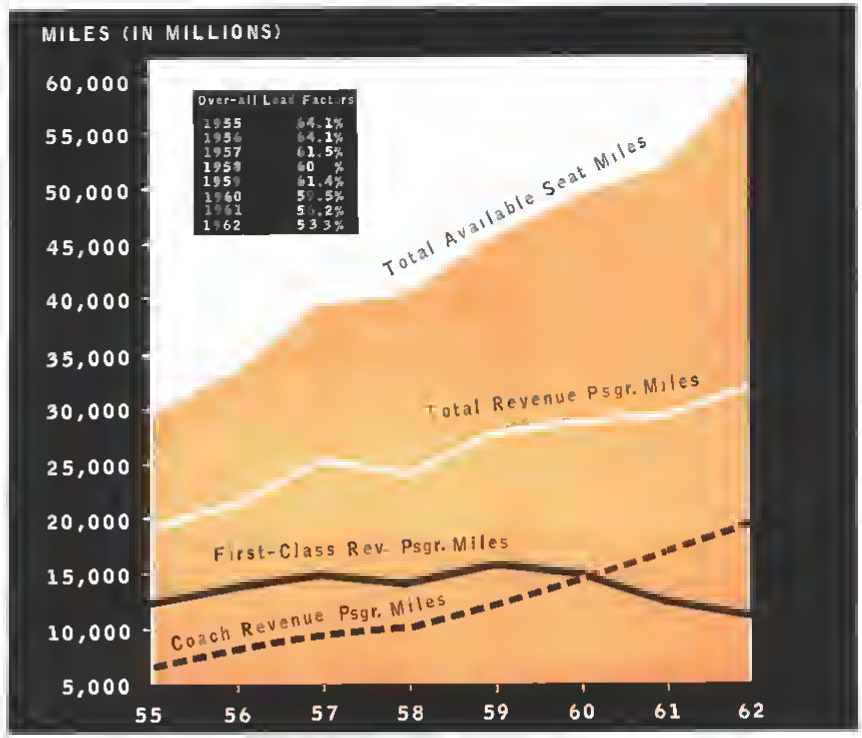
- **Redeye**, a shoulder-fired, Bazooka-type air-defense rocket, is built by General Dynamics/Pomona. It is about 4 ft. long, has a 3 in. diameter and is powered by solid propellant.
- **Mauler**, also built by General Dynamics/Pomona, is a solid propellant radar-guided air defense missile, mounted in batteries of nine on the back of a self-propelled chassis. It can also be used against ground targets.
- **Shillelagh**, primarily an anti-tank weapon, is built by Aeronutronic Div. of Ford Motor Co. It is powered by solid propellant and is optically guided.
- **TOW**, for tube-launched optically tracked wire-guided missile, is presently under development. Hughes Aircraft Co. is the contractor.
- **LAW**, for light assault weapon, is an individual soldier's weapon, about 25 in. long, 3 in. in diameter and propelled by a solid propellant. It is being built by the Hesse-Eastern Div. of Flightex Fabrics Inc. It is in production and soon will be issued to troops.

In early development:

- **Lance**, first Army missile to use pre-packaged liquid propellants. It is being built by Ling-Temco-Vought. A general purpose missile, it will replace the Lacrosse and Honest John.

Supersonic transport configuration studies at NASA's Langley Research Center include SCAT-16 (mounted on sting), powered by three podded jet engines. Variable geometry wings are fully swept back here. On tunnel floor is SCAT-15 (left), a variable sweep, four engine configuration, and (right) SCAT-4 with specially cambered, highly swept wing and engine nacelles at the trailing edges. SCAT stands for Supersonic Commercial Air Transport.

Air Transport



AVAILABLE SEAT MILES offered by U.S. domestic trunk airlines continue to outstrip total revenue passenger miles, and industry load factor is dropping steadily. Meanwhile, steadily increasing coach revenue passenger miles at the sacrifice of higher-yield first-class revenue passenger miles are threatening to take deep slices into overall revenues.

Airlines Split Over Mergers, Fare Goals

By L. L. Doty

Washington—Gradual improvement in the earnings of the U. S. scheduled airline industry during the next four years is now being forecast, but the reversal from 1961's loss is not being interpreted as a new trend toward industry-wide prosperity.

Chief problem facing the airlines is a wide split within the industry as to the best methods to strengthen their earning power and performance. Two camps have emerged during the past few years on the fare issue. Merger proponents, who see a solution in consolidation, are finding themselves under heavy industry attack and with outside support in doubt.

In addition, domestic trunklines are unable to decide among themselves whether the industry is fundamentally "sick," or "healthy." International carriers are at odds over how foreign flag competition should be met. About the only single point on which all carriers seem to be unanimously agreed is that industry expenses will continue to move upward.

Industry differences are deep-rooted and restoration of harmony will not come easily. Potential impact of the two proposed mergers—American Airlines with Eastern Airlines, and Pan American World Airways with Trans World Airlines—on the competitive structure of the industry is a prime cause of this dissension. Opponents of the American-Eastern merger have lost no opportunity to protest loudly and violently against the proposal.

Because of the far-reaching effect the Pan Am-TWA merger is expected to have on the competitive relationship between domestic and international operations, objections to it will evolve into industry strife equally as strident.

That a competitive imbalance already does exist is evident in the varying degrees of success now being experienced by 8 of the 11 carriers and the continuing losses being reported by the remaining three, Eastern, Northeast, and TWA. As a result, it is somewhat unrealistic to use total industry results as a

Comparative Direct Operating Costs—Domestic Trunklines

(Cents per plane mile, 12 months ended September 1962)

	Flying Operations	Direct Maintenance	Applied Maintenance Burden	Depreciation	Interchange Expense	Total Direct Operating Expense
DC-3	53 81	21 33	14 02	4 29		92 38
CV-240	59 29	40 39	46 40			145 31
CV-340	56 41	21 41	17 38	5 04	1 69	101 96
CV-440	54 63	17 55	13 97	26 42		114 11
M-404	55 96	21 66	13 14	0 93		91 17
DC-6	76 09	31 63	31 86	1 84	1 26	143 54
DC-6A	85 55	38 24	27 75	29 49		171 45
DC-6B	81 53	33 02	26 08	28 47	6 02	173 52
DC-7	79 89	41 15	31 52	50 91	2 91	206 72
DC-7B	77 16	30 49	23 04	56 79		187 13
DC-7C	83 98	42 71	22 73	45 76		197 36
L-049	81 83	12 52	17 09	17 93		138 02
L-749	87 53	36 08	30 99	14 83		169 89
L-1049	82 09	48 46	32 95	10 98		169 53
L-1049C	99 63	29 13	19 89	11 36		158 02
L-1049G	92 13	42 15	33 07	83 49		256 69
L-1049H	83 50	52 10	31 85	127 53		296 47
L-1649	97 34	31 13	33 69	260 12		423 01
C-46	45 05	34 64	25 28	12 66		107 62
Viscount	57 03	25 30	33 51	16 55		122 38
Electra	69 58	39 17	15 14	36 63		161 37
B-707 & 720	92 75	31 03	22 59	28 73		175 62
DC-8	91 35	30 65	20 14	35 58	4 76	183 90
CV-880	95 04	44 16	22 64	34 47		193 23
CV-990	129 18	36 62	29 65	35 21		230 44

Domestic Trunkline Traffic Activity During 1962 Compared with 1961

	Revenue Passenger Miles (in billions)		Available Seat Miles (in billions)		Load Factor (per cent)	
	1961	1962	1961	1962	1961	1962
January	2 34	2 61	4 11	4 82	56 9	54 1
February	1 81	2 33	3 12	4 43	57 9	52 6
March	2 39	2 67	4 17	5 10	57 3	52 2
April	2 45	2 73	4 17	5 05	58 7	54 1
May	2 37	2 65	4 33	5 17	54 6	51 3
June	2 81	2 94	4 60	5 04	61 1	58 4
July	2 65	2 64	4 77	4 73	55 7	55 8
August	2 78	2 90	4 84	4 97	57 5	58 4
September	2 53	2 69	4 60	5 00	54 9	53 8
October	2 53	2 64	4 73	5 36	53 5	49 3
November	3 36	2 45	4 58	4 95	51 5	49 5
December	3 53	2 57	4 51	5 11	56 0	50 3

full measure of the progress of individual airlines. However, such industry results do give clues as to the general trend of air travel business.

Consensus is that revenue passenger miles will grow at an average annual rate of 4% to 6% on domestic routes during the next four years and about 10% in the North Atlantic market—assuming a stable world wide economy. There is a general but understandable reluctance within the industry to risk a prediction of traffic activities in most foreign markets.

Expense level apparently has not reached its apogee and most airline economists insist that a leveling-off phase is not in sight within the next four years. Although interest costs and jet transitional expenses have reached a plateau, wage costs and costs of goods and services are expected to follow an unabated upward trend for the next four to five years.

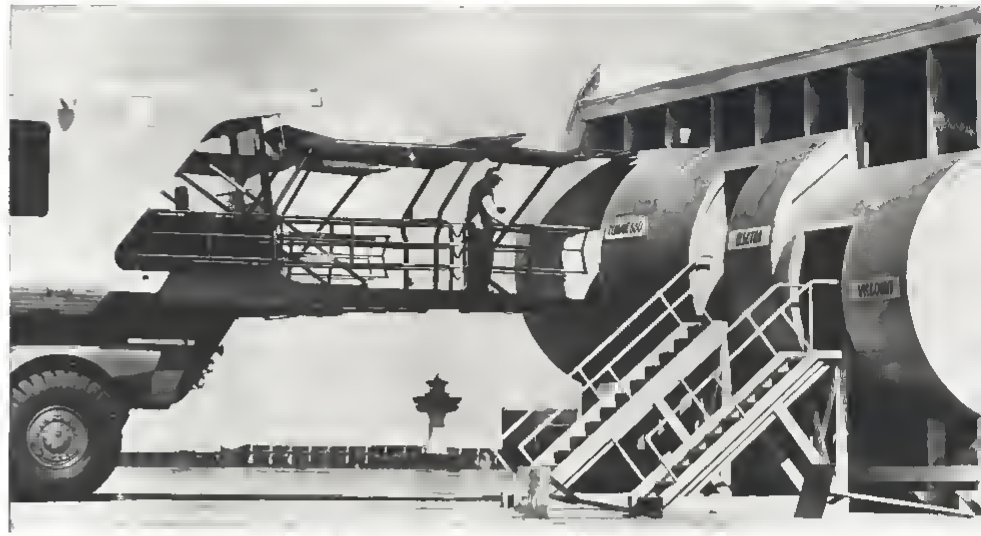
Cost control often is a dilemma, not just a problem. Eastern Air Lines, for example, had to weigh immediate loss of revenue against potential crew cost savings in the future in its drastic showdown with the flight engineers last summer over the crew complement issue. Difficult as the choice may have been, management still had the prerogative to make the choice. In some other cost areas, like rising terminal rent and landing fee charges, management often has little or no direct control.

Cost Estimates

Today's best estimates place average gross expense increases at a 3-4% annual rate during the next four years. Application of these projections on the assumption there will be no major disruption in the general economy suggest that it will be another five years before domestic trunklines will realize the 10.5% rate of return on investment before taxes to which both the industry and the government feel trunklines are entitled.

There is a minority group considerably more optimistic in its views. This group feels that the general pessimistic outlook stems from attempts by larger or dominating carriers to paint a gloomy picture as a means of underscoring the need for mergers or sidetracking drastic fare reductions. The recent rebellion of five smaller carriers against the alleged labeling of the industry as "sick" by American and Eastern is a manifestation of this attitude.

This group believes that the industry can surmount current financial problems without any uprooting of its present structure and that, by 1964, the industry will begin to move into a highly profitable era. Several economists within this group have estimated net earnings for the 11 trunklines of $30 million for 1962 and over $60 million for 1963.



NEW CONCEPT for passenger boarding was introduced at Dulles International Airport with Chrysler-designed mobile lounges. Ramp adjustment, over a range of 7 ft. vertically, was tested on mockups of various transports. Lounges carry passengers from terminal, in background, to aircraft positioned at relatively long distances from it on the field, eliminating the usual terminal fingers.

Among the pessimists, forecasts seem to average out at $12 million net profit for 1962 and $30 million for 1963. Air Transport Assn. has estimated a break-even status for the industry in 1962. AVIATION WEEK & SPACE TECHNOLOGY has predicted a $25 million net profit for 1962 (AW Nov. 19, p. 41).

Internationally, it is unrealistic to make a sweeping judgment of traffic activities and prospects in foreign markets because of the many divergent political and economic factors affecting each area. This diversity is the principal reason behind the varying policy approaches employed by the U.S. in the treatment of foreign air travel markets.

The Pacific area, for example, continues to show promising signs of extensive traffic growth. United Air Lines' 1962 profit of $6.3 million was bolstered to a large extent by a highly successful operation on its mainland-Hawaii route during the year. Military traffic also has benefited airlines in this area.

Braniff Airways is expected to show a loss on its South American operation, but it will be offset by a substantial profit from domestic route segments. On the other hand, Trans World Airlines reported losses from domestic services but profits from international operations last year. In TWA's case, however, allocation of costs tends to favor international results.

Pan American World Airways, with no domestic services, prospers on an over-all basis though not necessarily in all regions. Revenue passenger miles climbed 18% in 1962 over the previous year, and net profit for the year was $14.5 million for Pan Am, a 62.6% increase over net earnings reported in 1961.

Merger Issue

International Air Transport Assn. is forecasting a 13% increase in passenger revenue miles during 1963 on all international routes. In addition, a profit for the world airlines is forecast for 1963 by IATA.

Vitally important to future competitive alignments is the outcome of the proposed and suggested mergers, particularly the TWA Pan Am and American Eastern proposals. There are growing indications that the Kennedy Administration is not looking upon these mergers with any enthusiasm although there have been no definite statements to suggest that there will be outright disapproval of either or both. Support for the Pan Am merger is reported among individual cabinet members and congressmen, however.

Leaders of both companies strongly feel that the White House will follow the recommendations of the Civil Aeronautics Board which, through its Chairman, Alan S. Boyd, has periodically espoused mergers as one cure to the industry's financial ills.

One recent development cannot be overlooked in the evaluation of merger possibilities: recent backing of the CAB by the U.S. Supreme Court in the Court's ruling on Pan American and W. R. Grace & Co. ownership of Pan American Grace Airlines (AW Jan. 21, p. 42).

In its decision, the Court, in a 5-2 vote, said:

"Where the problem lies within the purview of the Board, as do questions of division of territories, the allocation of routes, and the affiliation of common carriers with air carriers, Congress must have intended to give it authority that was ample to deal with the evil at hand. It seems clear that such power exists." The Court said it refused to assume what was the CAB's responsibility.

CAB Role Strengthened

Lawyers here are still discussing the various interpretations being placed on the high court ruling. This much is certain, however: the CAB now has strong precedent in many areas where a doubt once existed. The only point left open to interpretation is whether this precedent also will be recognized by the White House, whose approval is required in international route cases.

In any event, the CAB is now clearly fortified with a new strength as an arm of Congress and it can be expected to use that strength.

At the same time, the U.S. has de-

Growth in Coach Traffic in 1962

	Revenue Passenger Miles (in billions)		Available Seat Miles (in billions)		Load Factor (per cent)	
	Coach	1st Class	Coach	1st Class	Coach	1st Class
January	1 61	1 00	2 81	2 01	57 3	49 6
February	1 45	0 88	2 60	1 83	55 8	48 2
March	1 66	1 00	2 98	2 12	55 8	47 3
April	1 72	1 02	2 97	2 08	57 7	49 0
May	1 67	0 98	3 04	2 13	54 9	46 1
June	1 95	1 00	3 09	2 00	64 2	49 7
July	1 80	0 84	2 86	1 86	62 7	45 1
August	2 00	0 91	3 05	1 92	65 5	47 2
September	1 83	0 86	3 13	1 88	58 6	45 6
October	1 75	0 90	3 35	2 02	52 2	44 5
November	1 63	0 81	3 11	1 84	52 4	44 3
December	1 80	0 77	3 28	1 83	54 9	42 0

veloped a policy on international air transportation which condemns the chosen instrument principle. The policy deplores the restraining of competition, opposes pools and suggests that any merger which will reduce competition is unpalatable. It is very possible that the temper of this philosophy will spill over into the domestic field to give anti-merger factions a boost.

The future of fare issues remains as clouded as the merger issue with two rate philosophies clashing with one another while middle-of-the-road factions fight both. At one extreme is Continental Air Lines, driving for a three-level fare structure. At the other is United Air Lines, advocating a single class rate structure. This plan has attracted the support of National Airlines but has drawn stiff opposition from United's chief competitors.

Plans Described

Continental's fare structure is based on the theory that air travel markets can be expanded sufficiently to surmount overcapacity only by introducing a broad range of fares and services catering not only to proven markets but with new low fare classes designed to lure travelers from the private automobile. Opponents say that low fares tend only to divert traffic from the higher-yield categories and don't attract enough new traffic to offset revenue losses. United's plan appears to be aimed rather at revenues and not traffic generation, in that it seeks to reduce the spread between coach and first class fares.

Chief benefit of the battle is that both fare structures are being put to test through experimentation so that statistical evidence of the value of each will be available. Although American Airlines last month said it would counter the United fare with coach fares and services comparable to those offered by United's one class fare, the two experiments may set the stage for an eventual stabilization of an air rate structure.

Thus far, opinions on the fare issue have been formed on theory or on short-lived test cases which have seldom been given the time to prove their worth. There has been little solid research undertaken to support the contentions of the opposing factions.

International carriers are as equally split on low versus high fares as U. S. domestic carriers but differences generally are thrashed out in IATA traffic conferences so that compromised formulas for a fare structure can be introduced in relative harmony on a world-wide system. U. S. carriers, of course, are restrained by anti-trust laws from discussing rate formulas among themselves.

Advocates of a rate boost in the international area were successful last year in preventing another fare reduction on grounds that a fare cut at this time would involve severe financial risks. However, low fare proponents gained some ground through the introduction of special low novelty fares as a means of testing various markets to determine whether a general fare reduction is practical within the next few years.

Coach Traffic

Dissension on rates stems from the rising volume of coach traffic and the dwindling first class market. Coach today is the dominating form of business in both the U. S. domestic and international fields and many airlines fear that this diversion will depress revenues.

Facts do not seem to warrant this fear at the present time. Domestic trunkline coach revenue passenger miles reached 20.8 billion in 1962, a 13% increase over the volume in 1961. First class revenue passenger miles totaled only 10.9 billion, a 17% decrease from the volume handled in 1961.

Nevertheless, according to latest estimates, the 11 domestic trunklines showed an 11% increase in gross revenues in 1962 compared to the previous year. These estimates also indicate that only Eastern Air Lines and Northeast Airlines failed to register a revenue gain during the year. All other trunklines showed substantial improvement in revenues.

Delta Air Lines and National experienced major gains in gross revenues, due principally to traffic increases on their new southern transcontinental routes. Carriers whose route structures and competitive postures remained stable reported less impressive advances.

United, with Capital's staff and routes securely absorbed into the overall operation, earned an estimated $563 million in gross revenues in 1962 compared to $517 million the previous year.

The year was the first in which United carried more passengers on jet aircraft than on propeller planes. United also showed a spectacular 15% increase in revenue passenger miles during 1962.

A series of mergers would, of course, have a decided effect on the route structure and competitive relationship of the domestic carriers. Beyond that, however, there are no major route cases pending that could cause a drastic readjustment of the domestic industry's makeup. Financial reverses could cause new proposed mergers but generally the merger fever that swept the industry in the last few years has cooled.

International Routes

On U. S. international routes, a complete revamping of the basic structure can be expected. The CAB is investigating both U. S. South American and North Atlantic routes with the avowed purpose of dividing the markets in those areas among the carriers on a regional basis. There is nothing in the new U. S. international policy on air transportation that would prevent the Board from pursuing this course fully and completely.

The Transpacific Route Service Case is still under review by the CAB and a Board decision that will revise the competitive relationship of U. S. carriers in this area is imminent.

Meanwhile, the close relationship between domestic and international routes is taking on new significance. Chances are now strong that foreign flag carrier inroads in U. S. markets will be brought to a halt. At the same time, U. S. carriers will expand their overseas operations to ports of entry in the U. S. to a greater degree than was heretofore considered economically practical.

This would give the U. S. carriers a competitive advantage over foreign flag carriers serving the U. S. but the pattern could change quickly if foreign flag carriers, particularly those serving the common market or those operating under international consortiums or pools, chose to retaliate by restricting U. S. fifth freedom operations on the European continent.

European Travel

Also, not to be overlooked is travel potential developing from within Europe, one that shortly could match the U. S. passenger market in the volume of consumer spending. U. S. carriers have historically worried over their declining share of traffic on the North Atlantic, particularly since the majority of travelers in this market are U. S. citizens. It is not illogical to assume that European travelers may some day constitute the larger portion of overseas travelers, giving European airlines an opportunity to strum the same refrain U. S. carriers have sung for the past 10 years.

The fact remains that the long-range capability of turbojet transports has broadened the scope of air travel and the historic ports of New York, Los Angeles, London and Paris will soon be facing competition from inland ports once considered purely domestic in function. First victims of the long range planes have been such refueling points as Gander, Shannon, the Azores, Kefla vik and Wake Island.

U. S. international airlines are still unable to find a common meeting ground as to how they should compete with foreign flag carriers. TWA faithfully has given its support to the regional concept proposed by the CAB for the North Atlantic markets. Pan American, on the other hand, has openly voiced its opposition to the proposed plan.

In the South American market, Pan Am has raised vigorous protests against the regional concept. Most all carriers serving the South American market are suffering losses because of excessive competition and Pan American holds that any restriction of U. S. operations in the area will only intensify a serious problem.

A number of Latin American carriers continue to operate at cut-rate fares and attempts by IATA airlines to circumvent this price war have not been too successful. The excessive competition question is further compounded by the imposition of capacity restrictions by several national governments against U. S. carriers.

Capacity restriction, which also exists in India and sometimes in Japan, has hampered the U. S. in the development of an air policy which can be applicable in all parts of the world. A policy which, for example, would serve U. S. purposes in Europe could be ruinous to U. S. airlines in South America.

Declining load factors are continuing to plague the airlines of the world. Available seat mile increases have steadily outstripped capacity gains since 1959 when jet transports were introduced into scheduled service in substantial numbers.

Load Factor

Domestic trunkline load factor fell to 53.3% in 1962, the lowest level reached since the late 1930s. Available seat miles rose 13.7% in that period while revenue passenger miles showed only a 7.8% increase.

Domestic trunkline coach load factor was 57.6% for 1962, compared to 60.2% in 1961. First-class load factor was only 46.7% compared to 51.6% in 1961. No doubt exists that the load factor of all airlines has fallen to a dangerously low level.

Airlines of the world are anticipating some relief from cost rises but, again, no leveling off in total operating expenses is foreseen.

Domestic trunklines experienced an estimated 9% increase in total operating expenses in 1962. Major steps toward the pooling of jet engine overhaul and maintenance have been taken by U. S. carriers in a move to retrench. Probability of extensive pooling of ground equipment is slight, however, and stiff competition has all but quashed any hopes for a revival of consolidated ticket offices or joint sales offices on a large scale.

Intercity Passenger Miles

(In Millions)

	1961	1962
Railroad Travel:		
1st Class	3,262	3,067
Coach	12,893	12,765
Total	16,155	15,822
Air Travel:		
1st Class	13,954	12,683
Coach	17,109	20,927
Total	31,063	33,620
Motor Bus Travel*	19,700	21,400
Total Common Carriers	66,918	70,852
Airlines share	46 4	47 5
Railroad share	24 2	22 3
Bus share	29 4	30 2
Private Automobile, Intercity	700,000	713,000
Total Common Carrier and Auto	766,918	783,852
Airline %	4 1	4 3
Railroad %	2 1	2 0
Bus %	2 6	2 7
Auto %	91 2	91 0

* Includes charters

Merger Argument

Merger backers claim that the main advantage of logical mergers is the reduced cost that comes from eliminating duplication of operating activities. Eastern and American have estimated that this factor alone will save the merged company as much as $75 million annually.

It has been estimated that the flight engineers' strike against Eastern in 1962 reduced domestic trunkline industry expenses by nearly $50 million while cutting revenues by approximately $33 million. According to one airline statistician, "If there had not been a strike, the industry would have only shown a break-even of revenues with expenses in 1962."

Carriers who believe the industry is "healthy" are convinced that traffic increases will bolster revenues in 1963 while expenses will not climb as rapidly as they have in the past. The pessimists take this view:

"The picture for 1961-1963 does not support the several statements made recently about the improved status of the domestic trunk airlines. The financial results are far short of the more than $275 million earnings before taxes that would have to be obtained at the present time to reach the standard rate of return on investment adopted as reasonable by the CAB. Merely to achieve a break-even basis is certainly no accomplishment, particularly in an industry with an investment in domestic operations of nearly $2 billion. This involves no return on the one-third which represents stockholders' investment and a most inadequate protection for the two-thirds advanced by lenders."

Speaking optimistically for the international carriers of the world, IATA Director General, Sir William Hildred, had this to say:

"It is, of course, difficult to look into the future with so sensitive an industry, but there is some brightening in the general prospects for world airline traffic. The rate of growth is again on the upswing and 1963 should see growth rates for passengers and cargo approximating the average over the past 10 years. . . . I do not think that I am being overly optimistic in hoping to see the airlines back in the black on their operating account this year, though one or two (airline) presidents have said I am too optimistic."

SECOND VICKERS VC 10 four-engine transport to roll out is the first for British Overseas Airways Corp. It will be used for systems development testing. Prototype, also in BOAC markings, is owned by British Aircraft Corp.

World Airlines Face New Consolidations

Consolidation and cooperation have become major influences on international airline operation, and carriers not involved in partnership proceedings are conducting long-range planning with a wary eye directed at Air Union and the proposed merger of Pan American World Airways and Trans World Airlines.

European supporters of Air Union believe the Pan American-TWA merger would insure the establishment of the consortium of Alitalia, Air France, Lufthansa and Sabena. By the same token, Pan American and TWA are pointing at the competitive threat of Air Union as a reason why their merger should be approved by the U. S. government.

Pan American carries more passengers than the four prospective Air Union members combined. Adding TWA's system to its network would strengthen this advantage. Consequently, Air Union associates feel that ratification of the organization's treaty will result despite dissension caused by France's rejection of Great Britain as a Common Market partner.

No Formal Bond

Air Union has not, from the beginning, been formally tied to the Common Market.

"We made it known," one spokesman said, "that we were not a fount from the Rome Treaty, which established the Common Market. We might in the future take in other Common Market countries, and possibly some non-European carriers. Our charter provides for this, but only in the second phase of the operation."

Few will hazard a guess as to when Air Union will become a reality. Ratification of its treaty by the four governments involved—France, Italy, West Germany and Belgium—will require considerable time.

Because Air France is the largest member airline, it has been generally conceded that once France approved the treaty the other governments would step in line quickly. But when France recently approved the treaty on a government administrative level, it insisted on changes designed to stiffen requirements for the purchase of common types of aircraft. If accepted, such changes might promote orders from all members for the Anglo-French Mach 2.2 transport.

Other carriers, however, hope to hold off any orders for supersonic transports until they see what U. S. manufacturers may offer. If France adopts a hard line in this respect, it could create obstacles to approval of the treaty by the various governments.

Another point under debate is the distribution scale that would give Air France 34% of Air Union's profits, Lufthansa 30%, Alitalia 26% and Sabena 10%.

Alitalia is now insisting in private negotiations that its continuing growth entitles it to a share larger than that allocated when it was still in the latter stages of postwar recovery. Under one proposal, Alitalia would receive 4% of Air France's current total, giving the three larger airlines an equal 30% split and leaving Sabena with the remaining 10%.

Another potential problem is KLM's move to join Air Union. It is pressured in this effort by the Dutch government, which is disturbed by KLM's continuing losses and consequent need for subsidy. Readjustment of the profit sharing arrangement to include KLM could touch off dissension. Some would allocate KLM only 6% of total profits, a figure well below what the airline believes it deserves, and reduce Sabena's portion to 4%.

Monogoriol Responsibility

Air Union still has to decide on how managerial responsibility will be distributed among the four carriers, and how much influence the various governments will have in policy areas of Air Union.

Officials connected with Air Union stress that there is no plan to merge the airlines. Despite reports as to the Air Union's eventual goals, these officials contend that each airline will retain its individual identity, fly its own equipment with little or no interchange and retain its own responsibilities in most areas, particularly in the maintenance of aircraft.

This attitude stems partly from national pride. Each nation wants to retain its own flag carrier for prestige. Another influence is realization that a merger would wreak havoc with the current bilateral rights structure, particularly so far as the United States is concerned.

What Air Union would do, one official said, is to use the existing bilateral rights in a more rational way through coordinating frequencies, schedules and interline exchange, especially on the North Atlantic.

Program Activation

To speed Air Union's activation, which has already dragged beyond expectations, the four carriers will implement the program as soon as the governments ratify the treaty, assuming that parliamentary approval in the various countries will follow without any delays.

Across the English Channel, the two British state-owned airlines are confronted with perplexities more immediate than the rise of Air Union. British Overseas Airways Corp. and British European Airlines are redoubling efforts to cut costs as London's share of transatlantic business declines, a result of the long-haul jets transport erasing its traditional position as Europe's major gateway.

Possibility of a merger of BOAC and BEA remains obscured despite strong efforts in government circles toward this end. Some British aviation authorities feel the merger prospect may brighten if its chief opponent, Lord Douglas of Kirtleside, does not seek reappointment when his term as British European chairman expires in December of this year.

BOAC is also under fire for its financial practices. Investigation into BOAC financing is now under way by Minister of Aviation Julian Amery, who criticized the carrier's extensive write-down last November of its Britannia fleet (AW Nov. 12, 1962, p. 41).

BOAC Equipment

Sir Matthew Slattery, BOAC chairman, retorted that the Ministry of Aviation has repeatedly refused to let the airline realistically depreciate the cost of its aircraft.

The Ministry of Aviation has also directly influenced BOAC's equipment policies and has pressured it into buying associate companies which consistently lost money, Sir Matthew has charged.

This is being interpreted as a move by Sir Matthew to force the government to decide whether BOAC is truly an instrument of national policy, and whether as such it should be compensated for losses arising from government influence.

In the words of Sir Basil Smallpeice, BOAC's managing director, business so far this year "continues to be disappointing."

Although BOAC's January passenger traffic was up 5%, increases have not been sufficient to offset last year's huge losses.

Revenues, since BOAC's financial year began April 1, 1962, have risen about $3 million to a record $196 million, Sir Basil said, but again the figure is not enough margin against potential 1963 costs.

BEA is likewise struggling to balance revenues and costs, after recording a $5 million deficit last year on internal United Kingdom routes. For relief, the Air Transport Licensing Board approved a 10% increase in fares on these routes.

Latest traffic-generation project by BEA is a walk-on service connecting London, Glasgow, Belfast and Edin-

Africa Modernizes Air Transport

Washington—United States will accelerate the pace of its economic aid for aviation development in Africa this year as the Western powers bid for stronger political ties with many former colonial possessions.

West Africa, and in particular the independent nations of Ghana, Guinea and Mali, may be the next most logical location for aviation development programs offered by the French, British and Americans. Soviet prestige and influence in these African countries has been set back to a large degree by Ghana Airways' costly experience with Russian aircraft. Agreement between the three African governments to form a jointly owned and controlled airline, could bring need for both new flight equipment and training programs.

Spearhead of the U. S. program will be aimed at building internal aviation networks, considering them as a less costly alternative to highway building. Majority of the financial support will come from Export-Import Bank loans and grants through the Agency for International Development.

Funding by U. S.

Last year an estimated $35 million in economic assistance was allotted by the U. S. for aviation development in Africa. Ethiopia received more than half of this sum with a Development Loan Fund loan totaling more than $22.6 million for the construction and equipping of airports.

In addition, the country was authorized a $9.9 million Ex-Im Bank loan for the purchase of two Boeing 320B turbojets and spare parts for Ethiopian Air Lines. As a comparative indication of the importance of aviation development in the country, U. S. aid for highway construction and improvement was only $3.6 million.

Majority of the balance of the total funds was spent for airport improvement, navigational aid, and technical training programs in Egypt, a total of $2 million, Tunisia, $5 million, and Liberia, $2 million.

The Egyptian government, recently awarded a New York-Cairo route, has also been in the market for an Ex-Im Bank loan to purchase five Boeing long-range turbojets. Discussions on the purchase and loan were still in process at the turn of the year.

Egypt, as well as Ethiopia, serves as an example of how U. S. aid has been utilized in Africa's program to build and improve a modern airways system.

Egypt Modernizes Airways

By the end of this year, a three year AID program will have been completed by both Egypt and the U. S. Total cost of the air transport program will be $11 million with the United Arab Republic contributing $8.1 million of the funds to the program.

A modern airways system plan has been completed and work started on the installation of equipment. On-the-job training programs are being carried out, with 54 participants having been trained in the U. S. and Europe and another 10 scheduled for training this year.

Broad objectives of the program have been:

- Assist the Civil Aviation Department of the UAR in planning a modern airways system and the facilities to implement the system.
- Provide electronic and electric equipment for the facilities scheduled for installation by the end of this year. Equipment includes visual omni ranges at seven locations, approach control radar for Cairo International Airport, very high frequency radio communications systems for air traffic control use, and low powered beacons at several points to serve as holding points for traffic in the Cairo area.

North Atlantic Traffic—1962

FLIGHTS	Eastbound	Westbound	Both Ways	% Change over 1961
Economy	1,790	1,892	3,682	+56 5%
Mixed	15,463	15,395	30,858	+10 9%
Total Passenger	17,253	17,287	34,540	+14.4%
Cargo	2,311	2,201	4,512	+11 8%
Total	19,564	19,488	39,052	+14 1%
SEATING CAPACITY				
First	323,002	321,952	644,954	− 1 3%
Economy	1,880,817	1,880 756	3,761,573	+21 6%
Total	2,203,819	2 202 708	4,406,527	+17 6%
REVENUE PASSENGERS				
First	102,033	106,142	208,175	−15 0%
Economy	991,141	1 072,847	2,063,988	+23 3%
Total	1,093,174	1,178,989	2,272,163	+18 4%
AVERAGE LOAD FACTOR	49 6%	53 5%	51 6%	+0 4
CARGO (tons)				
Pass. Flights	22,846	21,311	44,157	+25 5%
Cargo Flights	19 525	15,985	35,510	+28 4%
Total	42,371	37,296	79,667	+26 8%
MAIL (tons)				
Pass Flights	9,579	6,919	16,798	+18 5%
Cargo Flights	4,449	1,461	5,910	− 0 6%
Total	14,328	8,380	22,708	+12 8%

Source: Economics and Statistics Section
IATA Financial Department

burgh, using a one-third fare cut as a passenger incentive. While not a shuttle in the sense of Eastern Air Lines' U S operation, the proposed service does offer the low fares only to those persons who are willing to stand by and take the seats that are left over by reservation travelers.

Market Expansion

The experiment, to run from April through October, has been approved by the licensing board, which shares BEA's hope that a market expansion will result to ward off the need for further increases in fare levels. Increase in available tourist seats on the London-Belfast route would be 17%, the London-Glasgow run 21%, the London-Edinburgh 26%.

Stabilization is evident in the British independent airline situation, held in line by stiff government insistence on proof of financial stability before routes are awarded.

Still, the independents stand to reap a sizable share of tourist charters and government military contracts within the next few years. British United Airways, the largest of the 16 independents, is buying four Vickers VC 10s for African service and 10 BAC 111 short-haul transports.

British United, owned primarily by surface shipping interests, carried 1.7 million passengers in 1962, 89,000 tons of freight and 141,700 vehicles. Its car ferry service, using Bristol freighters and the Carvair DC-4 conversion, is expected to double in volume next year on routes to the Continent. British United's financial statistics filed with the British Board of Trade indicate that the airline netted about $2 million last year.

Although the independents are solidi-

flying their position, pressure exists that would keep them from competing directly against the two state-owned airlines. They face restriction from the Minister of Aviation, whose office blocked Cunard Eagle's attempt to compete with BOAC on the North Atlantic.

M. D. N. Wyatt, chairman of British United, said it is questionable whether the independents can survive in regulated competition against the two state-owned corporations. They must seek their own financing while the government supports BOAC and BEA with as much consideration for national prestige as for commercial practicality. Furthermore, the independents must bargain for financing in an English money market where lenders regard aircraft as costly, hazardous items with all the credit security of a tramp steamer.

Both the state and independent airlines are watching with interest a "get tough" policy in British negotiations for bilateral rights. First indication was demands on the Israeli carrier, El Al, Britain asking for more concessions in Israel if El Al expects to continue its present fifth freedom rights through England (AW Feb. 11, p. 47). This shift indicates Britain's concern over its currently diminishing role as European gateway.

Independent Ireland's Irish International Airlines continues to burgeon. Its 80,327 transatlantic passengers in 1962 represented a 47% increase over 1961 and its 59.1% load factor was the highest among North Atlantic carriers. The airline is shooting for $3,640,000 in additional revenues in 1963, and $25,200,000 of its forecast $33,600,000 in revenues is targeted to come from abroad.

Faced with added BEA competition in Europe, the Irish are counterbalancing it to a degree with new car ferry services from Britain to Ireland, a service it may extend from Dublin to Cherbourg.

In every overseas market the unrelenting diversion of passengers out of first class into the economy sections makes profits elusive in spite of larger volumes. Trans-Canada Air Lines, for example which in 1961 reduced fares to boost volumes, had to ask for an upward adjustment of rates on its domestic routes last year. The move increased its return per passenger mile from 5.8 cents in 1961 to 6.04 cents in 1962. Of TCA's 4 million passengers in 1962, 87% rode economy. At year end, Trans-Canada could only report that its deficit, compared to 1961, was "substantially reduced."

Future of the Caribbean market is awaiting new route arrangements arising from the recent independence of Trinidad and Jamaica. British West Indian Airways (BWIA) was sold by BOAC to Trinidad and Barbados and may be reorganized into a smaller, independent carrier serving island points without any U.S. linkage.

Puerto Rico continues to be the main Caribbean traffic center, accounting for the major part of Trans-Caribbean Airways' 65% increase in passengers during January. However practically all of the New York-Puerto Rico traffic travels on fares as low as $57.75 for the 1,612 mi. trip. Pan American credited Puerto Rico with providing half of its 1,522,000 Latin American Division travelers in 1962, but said "the low fare fails to offset mounting costs in flight operation, maintenance, aircraft and traffic services."

Talk of a South American air union involving five airlines, arose during 1962, a year which brought little if any change in the financial welfare of carriers engaged in the highly competitive struggle that still characterizes South America's airline industry.

Prospect of a consortium is unlikely because of the strong individualism of South American nations. Even those who have been approached by Avianca indicate only mild interest, feeling such a project would founder in the early stages of deciding how administrative control and profits would be allocated.

Panagra's effort to extend its routes into the U.S. has been handed back to the Civil Aeronautics Board by the Supreme Court.

In the Pacific, airlines are anxiously awaiting the lifting of Japanese government restrictions on foreign expenditures. Tourism out of Japan has been insignificant since World War 2, since air travel outside the country, except for business or government purposes, cannot be paid for with yen.

"Japan's economy is growing to the extent where international banking sources are starting to call for a halt to such monetary restrictions," one spokesman said. "But no one can estimate now whether the ban will be lifted in a year, two years or when."

Officials of airlines flying Pacific routes believe there is a rich potential of tourist travel to be tapped in Japan, volumes that would balance the heavy flow of traffic into the island nation.

Japanese banks, in a variation of the "go now, pay later" travel credit plan, are promoting "pay now, go later" accounts for those who wish to save toward the day when they can travel.

Despite the restrictions, Japan Air Lines' transpacific traffic was 5-10% higher in 1962. Additional DC-8 acquisitions will enable the Japanese carrier to increase frequencies to the U.S. to 11 weekly this year, four more than in 1962. Japan Air Lines is watching the CAB's Pacific Route Case with interest, and would probably gain added concessions into the U.S. if Pan American were awarded improved service, such as non-stop New York to Tokyo authority.

While 1962 did bring some relief from the heavy losses of 1961 to carriers throughout the world, the majority of foreign flag airlines could only report that their deficits were smaller. Although 1963 is expected to bring further passenger increases—approximately 13% worldwide—continued heavy competition, overcapacity and cost factors outside airline control will probably keep revenues or earnings below desired levels.

International Air Transport Assn. reported an 18.4% gain in transatlantic volumes in 1962, with 2,272,163 passengers carried. But average load factor was 51.6%, only half a percentage point over 1961, as flight frequencies increased to 39,052, a 14.1% increase.

Within Europe the 14 member airlines of the Air Research Bureau continued deficit operations on intra-European networks. Shooting for an estimated breakeven load factor of 60% in 1962, they managed only to match the previous year's 55.4%, reflecting an 11% gain in available seat miles. Most active area was on routes to the Iberian Peninsula, particularly Spain, where a 47% increase in capacity was accompanied by a 40% growth in passenger volumes.

SUD AVIATION CARAVELLE 6R for Austrian Airlines is one of two ordered by the carrier.

FIRST BOEING 707-320C jet cargo transport—scheduled for delivery to Pan American—makes its initial flight

Carriers Begin First Move Into Jet Cargo

By James R. Ashlock

New York—Widespread evaluation of all-jet cargo aircraft is under way against a backdrop of continuing increases in freight volumes and the competitive threat posed by carriers that will put these all-jet cargo aircraft into service this year.

Universal sharing of air cargo's growth, because all operators use generally the same type of aircraft, is expected to diminish as the jet freighter fleet expands and wins a larger proportion of long-haul carriage.

While the jets may absorb a greater part of the market, consensus is that the improved service they represent will also promote continued growth of over-all cargo volumes. Air cargo ton miles throughout the world in 1962 totaled 2,020 million, a 19% increase over 1961. International Air Transport Assn. is forecasting that 1963's volume will rise another 20%.

On the North Atlantic, 18 carriers lifted 87,600 tons of freight in 1962, a 27% increase over 1961.

On U.S. domestic routes, trunkline freight revenue ton miles in 1962 rose 19% to 473,954,000. The ton-mile total for all domestic carriers—including local service, helicopter, all cargo, intra-Alaskan and Hawaiian—was 629,390,000, an increase of 18.8%. Domestic trunk mail ton miles increased 9.7% and express 12.5%.

Seven airlines have firm orders for 19 jet freighters. The breakdown:

- **Douglas DC-8F**—Trans Canada Airlines ordered five, Trans Caribbean Airways two, Capitol Airways one, and Trans International Airlines one.
- **Boeing 707-320C**—American Airlines ordered four, Pan American World Airways three, and World Airways three.

Flying Tiger Lines has a tentative order for two DC-8Fs, and Pan American may acquire as many as three more Boeing 320C long-range cargo jets.

Cargo managers who must compete against this equipment with converted Constellations, DC-7s and turboprop freighters are voicing obvious concern. Some are telling their managements that unless they obtain jet cargo aircraft, business will be lost.

Impact of the cargo jets will be greatest in the transcontinental and transatlantic markets. Because of their greater capacity and speed, jets can wait longer into the night for their loads, giving shippers more time to assemble consignments without compromise on destination arrival time. Their smaller ton mile operating costs, as opposed to piston planes, may ignite campaigns for lower rates.

"The freight shipper is only interested in service," one trunkline cargo official said, "and those with the jets can give better service."

Another major trunkline cargo operator whose airline remains undecided on jet freighters is already forecasting his losses in mail and express, which he describes as "the cream off the top."

Arrival of the jets brings complications for both all-cargo airlines and carriers catering to passengers and cargo.

Those relying on cargo and charter passengers have been told by the Military Air Transport Service (MATS) that turbojet operators will be favored for military personnel movements, vital business in this field.

Although Flying Tiger is concerned to the point of trying to buy jets, and Slick Airways is looking at the available models, Richard M. Jackson, president of Seaboard World Airlines, is reacting differently. He said recently that cargo volumes don't yet justify the capacity and high utilization requirements of the jets, and that they will have very little effect on transatlantic cargo business.

Jackson said that the slight cost advantage of jet cargo planes over the CL-44 becomes meaningless unless sufficient payload is generated. The cargo jet's added speed may bring excessively low utilization, he said, and its noise may subject it to airport restrictions against late night takeoffs.

"It is improbable that any one North Atlantic airline can operate all-cargo jets successfully in commercial service for years to come," Jackson said, "primarily because none has developed sufficient cargo revenues to warrant the high capital expenditures and operating costs of a cargo operation."

Jackson credits the CL-44 with helping Seaboard to reverse its losses, which totaled $14.5 million between 1957-61, into a $900,000 profit on 1962 gross revenues that totaled about $23 million.

Few if any challenge Jackson's reasoning so far as the present is concerned. Hedging against the risk of overcapacity is indicated by the fact that all buyers of cargo jets except for American, are obtaining convertible models adaptable to either passenger or cargo use. Trans-Canada's first service with a DC-8F, scheduled to begin this month on transatlantic schedules, will feature 117 high-density passenger seats and space for 8,000 lb. of palletized cargo.

The airline says one or more of the five DC-8Fs it has ordered may be converted to all-cargo configuration, if and when the demand warrants it.

Most cargo authorities agree that when jet size volumes do develop, those in the best position to capitalize on them will be the carriers who started preparing soonest. American has made the fastest, and most extensive, start in the domestic market. Its initial all-jet cargo service slated for inauguration in November, will be with an all-cargo Boeing 320C.

Pan American in the transoceanic field, is likewise optimistic, having announced that it will put one of its three Boeing 320Cs in all-cargo service between Japan and San Francisco in May. The other two are scheduled for transatlantic service. Pan American flew 200 million cargo ton miles in 1962, a record 22.2% increase. Its North Atlantic volume alone rose 25.5% over 1961.

World Airways, a supplemental car-

Air Cargo in Scheduled Service 1961-1962

	THOUSANDS OF REVENUE TON-MILES					
	Mail		Express		Freight	
	1962	1961	1962	1961	1962	1961
DOMESTIC TRUNKS						
United/Capitol	51,107	50,961	17,164	16,370	126,471	103,691
American	32,261	26,214	15,031	11,872	153,747	124,985
Trans-World	21,156	18,762	9,909	8,999	63,649	58,762
Eastern	13,675	16,352	5,832	6,488	27,665	27,721
Delta	12,098	9,073	5,971	4,176	31,020	19,178
National	5,662	4,564	1,259	898	19,549	12,155
Northwest	8,587	6,202	3,784	2,339	19,404	11,899
Braniff	6,071	5,053	2,444	2,267	13,693	11,165
Western	3,909	3,365	1,342	1,114	5,706	4,026
Continental	3,746	3,154	1,394	1,516	9,708	7,358
Northeast	1,941	1,963	750	706	3,342	3,216
Trunk Total	160,213	144,683	64,880	56,745	473,954	384,156
LOCAL SERVICE TOTALS	3,832	3,355	3,772	3,019	7,220	5,495
ALL CARGO						
Airwise					2,373	1,836
Flying Tiger	193	364	345	381	73,658	66,003
Riddle	259	389	72	374	10,548	17,660
Seaboard	11,046	12,416			57,012	36,549
Slick	11		16		4,625	
All Cargo Total	11,509	13,169	433	755	148,216	122,048

Source: Ray & Ray

TRANS CANADA AIRLINES took delivery this year of the first DC-8F convertible jet cargo-passenger version.

ner, is going after MATS business on Pacific routes, planning to use its three Boeing 320Cs to link the West Coast with Honolulu, Wake, Guam, Manila, Saigon, Bangkok, Tokyo and Okinawa. Trans-Caribbean, with two convertible DC-8Fs, can capitalize on the rapidly growing demand for both cargo and low fare passenger service between the U.S. and such island points as Puerto Rico.

Difficult Decision

Decision to invest upwards of $7 million apiece on cargo jets isn't an easy one for airline managements to make, and cargo officials of many carriers are finding their boards of directors skeptical.

Even though cargo is exceeding passengers in annual growth percentage, the men who control the financing still note that the 2 billion cargo ton miles flown worldwide in 1962 was far below the 81.5 billion passenger miles in the same period. They also wonder at the need for jet freighters when 70% of most airlines' total cargo volumes is carried on passenger jets.

This hesitancy to assume added equipment debt based on cargo's potential is, in one sense, viewed as an advantage for the over all cargo business, since it may stem the threat of an over-capacity situation developing like that on the passenger side.

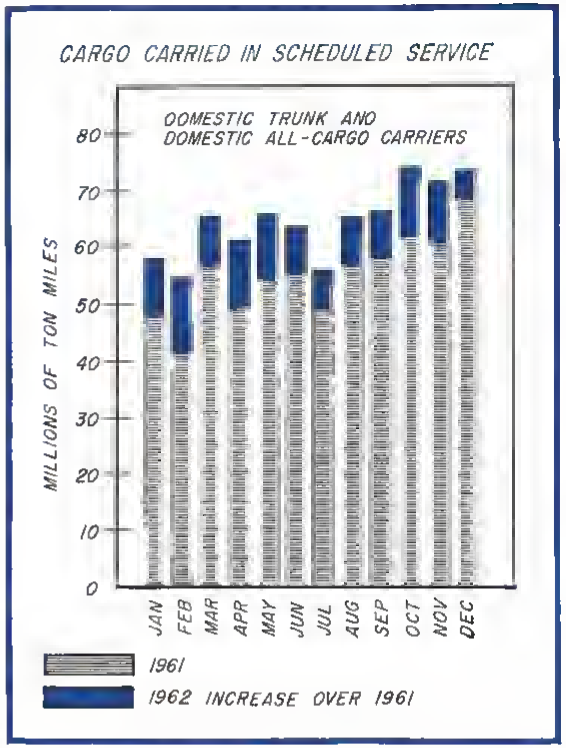
However, more cargo jets will be ordered, with United Air Lines' order for DC-8Fs the latest in the series of purchases. R. L. Mangold, vice president of cargo sales for United, has said that his airline will not sacrifice a competitive advantage in the cargo market.

United, whose transcontinental cargo volumes are complemented by a strong shorter-haul, high dollar business on extensive regional routes, reports volume rose about 28% and revenues 19% in the past year.

Cargo Growth Rate

Mangold isn't anxious to lose any of this growth to American's jets, which in 1964 will undoubtedly bring American a greater cargo growth rate than even the 22% increase in 1962. American's freight revenue ton miles totaled 153,747,000 in 1962.

Trans World Airlines is in the unenviable position of watching both Pan American and American equip for jet cargo service in both of the markets TWA serves, transatlantic and transcontinental. With its passenger jets, backed by six weekly North Atlantic Constellation cargo schedules and one cargo flight daily across the U.S., TWA has more than doubled its cargo volumes in the last three years. Cargo, on an annual basis, is accounting for as much as 20-25% of TWA's transatlantic revenues.



In 1962, TWA flew 64,524,000 ton miles of freight, mail and express across the Atlantic, a 44.2% increase over 1961 resulting in a 33% rise in transatlantic cargo revenues. Including its domestic service, TWA's systemwide cargo volume was 21.3% higher in 1962 and revenues rose 18.8%.

Continuance of this growth may be stunted considerably by the competition's jets, and TWA's management is trying to find ways, despite the carrier's heavy debt burden, to finance cargo jet acquisition.

Among foreign flag carriers, question marks still exist so far as turbine-powered freighters are concerned. Alitalia's interest in the DC-8F is generally known, but its equipment plans are contingent on whatever aircraft agreements are adopted by Air Union. The same applies to its Air Union partners, Lufthansa, Air France and Sabena.

British Overseas Airways Corp.'s consideration of the CL-44 remains shelved while attention is devoted to improving the carrier's over-all financial picture. In the Pacific market, Japan Air Lines may buy at least one DC-8F.

Evidence of the growing cargo business between the U.S. and Japan was Northwest Orient Airlines' 31,824,000 ton miles of freight flown in 1962, 53.8% boost over 1961. Northwest's express ton miles jumped 56% in 1962, and mail ton miles rose 21%.

Rate Battle

Rate battle between those wanting further rate reductions to spur more volume, as opposed to those who say rates are low enough for the service offered, is continuing.

Some extra business is expected from the new IATA rates that become effective in April—rates that offer advantages for frequent high volume shippers.

But domestically, a general sense of uneasiness is evident over some efforts to drive the rate level even lower. Flying Tiger is making a strong bid for business with what it calls "the lowest air freight rates ever offered to shippers," approximately 6 cents a ton mile.

U. S. Local Service Airlines

SELECTED OPERATING STATISTICS—1962

	Rev Plane Miles (000)	Rev Passenger Miles (000)	Passengers Originating	Passengers Enplaned	Orig Passenger Journey	Average Passenger Load	Passenger Load Factor (%)	Total Rev Ton Miles (000)	Ton Mile Util (%)	Avg Rnn Load (Tons)	Performance Factor (%)	Revenue Hours	Oft-Op Speed	No of Departures	Avg Length of Hop (Miles)
Allegheny	10 673	206 339	965 731	993 635	311	10 1	43 6	21 422	43 8	2 03	93 8	39 621	179 0	96 323	110 8
Bonanza	5 446	100 770	436 089	433 027	233	20 0	52 6	10 793	53 4	1 98	99 0	34 989	217 9	39,516	337 8
Central	7 294	70 364	334 208	348 036	211	9 6	37 3	7 587	36 4	1 03	97 9	46 699	156 2	84 362	86 6
Frontier	10 319	181 790	375 847	414 119	271	18 0	36 6	11 118	37 1	1 01	98 1	59 063	170 4	94 958	107 6
Lake Central	4 349	70 387	435,523	444,373	162	11 2	39 4	7 579	41 3	1 31	96 6	43 796	143 1	82 978	74 7
Mohawk	10 341	211 335	1,036 476	1 031 281	306	20 4	47 4	21 371	44 9	2 08	94 3	58 577	173 9	93 931	111 5
North Central	13 103	191 113	1 046 873	1 123 393	163	13 6	40 8	20 552	43 6	1 33	98 6	96 170	157 9	101 312	89 5
Ozark	9,393	134 190	673 764	661 368	183	13 9	47 3	13 161	31 6	1 37	98 1	63 193	131 8	107 341	89 4
Pacific	5,483	112 982	495,633	504 093	228	20 6	49 5	11 204	50 1	2 04	94 1	30 384	182 3	55 863	98 1
Piedmont	9 292	153 198	666 130	724 232	228	16 4	44 9	13 836	47 1	1 71	96 2	56 572	176 3	107 472	86 5
Southern	9,172	33 633	503,386	318 288	190	10 4	36 3	10 184	39 1	1 11	96 3	57 771	138 8	184 976	87 4
Trans Texas	8 117	92 433	381 807	409 339	238	11 4	37 4	9 835	37 9	1 21	97 9	42 938	188 3	80,948	108 3
West Coast	6 936	91 660	373 324	441 568	246	13 3	40 6	9 318	41 9	1 34	97 3	42 319	163 1	73,533	96 9
Average	114,036	1,627,006	7,710,708	8,119,285	211	14 8	42 5	170,812	43 0	1 49	97 1	686,893	186 9	1,293 269	94 8

Prepared by Roy & Roy

Subsidy Cut Threatens Class Mail Gains

By Robert H. Cook

Washington—Local service airlines face a crucial turning point this year as mounting pressures for drastic subsidy reductions dampen the industry's prospects for future growth.

Despite more than a decade of steady progress, the small "grass roots" carriers have been unable to achieve any significant lowering of the subsidy rate, which currently provides the industry with $5 for every $10 earned from the carriage of passengers and freight.

Measured in terms of available seat miles, the local carriers now provide about 80% more service for each $1 of subsidy than they did 10 years ago. Between 1951 and 1961 their unduplicated route miles expanded from 28,500 to 52,000 with available seat mile costs held constant, or even lowered in some cases as compared with 1951.

While these statistics are a source of pride to the local service airlines, they have been lost on subsidy critics who counter that the industry achieved only a 42.5% load factor last year against a 68% break-even requirement. In 1951 subsidy payments per load factor point averaged $500,000 compared to $1.6 million last year. The industry's 5.5% gain in average load factor during this period was made at a subsidy cost of about $9 million per point.

Neither new route awards nor purchase of new aircraft, accepted, though sometimes with reluctance, by the Civil Aeronautics Board as prerequisites to eventual subsidy reduction, has shown any positive sign of lowering the subsidy bill.

Route awards have included a high percentage of uneconomical points requiring heavy subsidy support. The new aircraft have proved efficient and economical only in high density traffic areas which account for a small percentage of the local service market. Reflecting the cost impact of the flight re-equipment programs are direct operating costs per aircraft mile that 10 years ago averaged only 46 cents but today are 97 cents.

President Kennedy's directive to the CAB last year that a program be developed with annual targets for a sharp reduction in operating subsidies spurred these developments:

● **Class mail rate subsidy formula** revision, begun by CAB to reduce record profits and subsidy earned by locals last year.

● **CAB planning report** recommendation that the subsidy bill be reduced to $35 million by 1970, with payments formulated through a comparison between the value and subsidy cost of local airline service as compared to other subsidized transport and non-transport businesses. The local carriers would be limited to a strict annual dollar budget requiring that operations be adjusted to meet customer demand. The latter is currently being accomplished, partially, through use of the class mail rate system.

● **Alteration in strategy** by the local carriers. Past campaigns have emphasized the need to drop nearly 25% of their unproductive points under the Board's Use-It-or-Lose-It program. Current thinking is that these points numbering about 125, should be retained. The carriers feel they could earn sufficient new revenue to offset the subsidy cost if the CAB would award them access to more cities being dropped by the trunks, and in addition, authorize the small carriers to compete directly against the trunks in high density traffic areas.

● **Developing controversy** over the third level type of carrier. Previous local carrier insistence that CAB accelerate the Use It or Lose It program and drop subsidized service to many small communities helped to spawn this new class. Now the locals contend that if such service is approved by the CAB, they are better qualified to provide it. A third level type service would use light twin aircraft to provide scheduled service to small cities facing loss of service, and to many others which have never had airline service.

● **Exploration** by CAB and the local service carriers of development of new aircraft suitable for primary use on low density traffic routes. Such aircraft would have a direct operating cost per plane mile well below that of the DC-3.

Optimism which initially engulfed the local carriers during early use of the class mail rate subsidy formula is fast receding as the airlines face significant cuts in subsidy and profits under the proposed revisions.

Basically a method of limiting subsidy to a CAB determination of adequate scheduling over route segments, the class mail rate increased the industry's net operating income from $2.1 million in 1960 to $9.3 million the following year and to $13.9 million last year. Net profit after taxes and interest increased from $1.9 million prior to introduction of the class rate to $4.8 million in 1961.

CAB's subsidy reduction program began with a revision to the rate effective Jan. 1. It calls for a set scale of subsidy rates per available seat mile on a formula which would produce a gross subsidy bill of $69 million this year. Following this revision, described as halting the upward trend of subsidy, the Board has planned a second revision, effective July 1, which will provide an automatic reduction in subsidy scale per available seat mile.

This rate will reduce the industry's gross subsidy bill by $1.5 million and leave a net subsidy total of $66 million after profit sharing provisions of the formula have been made. Thus, the revision amounts to a $3 million cut.

Maximum subsidy rates of 2.82 cents per available seat mile on a DC-3 and 1.926 cents for other aircraft will be paid under the July revision on an aircraft departure schedule of 4.75 a day. Seat mile rates reach their lowest point at the maximum allowable eight departures a day.

Net effect will be to force a general reduction in local service scheduling. As a balance the local carriers are likely to seek CAB approval to overfly many points in an effort to schedule longer, more profitable flights.

Concerned that subsidy may be withdrawn at a rate that could damage both its financial condition and ability to provide short haul service, the local carriers have appealed to CAB to approach subsidy reduction in this manner:

● **Authorize the local carriers** to serve dense, short haul markets on a non-competitive basis, and speed the transfer of several medium sized cities to the local service system.

● **Permit more competitive** nonstop service by local service airlines in the largest traffic producing market areas. An area-by-area investigation could identify the markets where this type of authorization would reduce subsidy needs.

● **Go slow** in Use It-or-Lose It proceedings to ensure that the intent of Congress for adequate local service is being met and avoid the demand for a separate third level network. Isolation of the community in question should be considered. In addition, the average length of haul should be reviewed to see whether the total passenger miles generated by the station are substantial.

● **Continue the Regional Airport** investigation. Local carriers feel that economies can be achieved under this program of consolidating area airline facilities.

For their part, the local carriers should establish:

● **Joint service cost committee** seeking to reduce over-all labor costs. The committee, to operate on a continuing basis, would also explore the use of a central reservations system.

● **Airport committee** to seek a more equitable formula of airport fees for local carriers operating at larger airports. To encourage this goal the Federal Aviation Agency should set fees for subsidized airlines wherever it has authority.

In general, the local carriers believe that if the CAB would permit them to serve 10-15% of the domestic revenue passenger miles, as opposed to only 4.2% in 1961, the entire local service route system would be adequately served and there would be little controversy over subsidy.

Meanwhile, the third level carriers have filed 18 applications for certificates with the CAB. The first of these applications, by Hi-Plains Airways for service over a six state area, was rejected by a CAB examiner last year. The case has not been taken under consideration by the full five-member CAB, but the examiner's decision, combined with the current program to reduce subsidy, may influence the fate of the remaining applicants.

Examiner Richard A. Walsh based his rejection on grounds that Hi Plains would require at least $1 million in subsidy to provide the service with a fleet of 11 Aero Commander 500B six place aircraft. Over-all subsidy costs

AERO GRAND COMMANDER fuselage is stretched 6 ft. 2 in., seats 11.

Local Service Airlines

Revenues and Expenses Year Ending Sept. 30, 1962

	Operating Revenues: Passenger	Operating Revenues: Total Non mail	Operating Revenues: Mail and Subsidy	Operating Revenues: Total	Total Operating Expense	Operating Profit (or Loss)
Allegheny	$13,056,497	$16 270 099	$6 756 800	$23,026,899	$21 099 579	$1 907 320
Bonanza	6 994 335	7 275 213	3,228 835	10,504,048	8 987 213	1 516,833
Central	5 047 333	5 496 717	4 656 376	10 153 093	9 658 733	494 360
Frontier	7 463 509	8 100 912	7 228 094	13 357 006	14 656 259	680 747
Lake Central	5 486 536	6,292,149	4 335 851	10 628 000	10,254 363	273 633
Mohawk	16 263 243	17,620,890	5 039,438	22,660 348	21 705 974	934,273
North Central	16,444 717	17,719,845	8 455 134	26,374 979	25 103 872	1 271 107
Ozark	8,793 030	9,334,969	4,814,760	14,339 729	13 498 249	841 480
Pacific	7,223 227	7 536 875	4 230 086	11 766 981	10 932 836	834 135
Piedmont	11,038 228	11,978 802	4,889 035	16,859 055	15 028 570	1,830 285
Southern	7 272 474	7 883 140	5 103 798	12 990,938	12 101 937	888 893
Trans-Texas	6 240 457	6,707,507	4,864 865	11 652 372	11 318 043	334 329
West Coast	6,786 473	7,139,177	5,483 294	12,642 571	11 300 765	1,241 806
Totals	120,335 079	129 648 295	66 268 816	196 016,911	185, 547 405	13 369 806

Prepared by Roy & Roy

Local Service Aircraft

4th Quarter, 1962

Carrier	DC-3	Martin	Convair 240	Convair 340 440	F-27	Total
Allegheny		16		16		32
Bonanza					11	11
Central	18		6			24
Frontier	22			9		31
Lake Central	20			5		25
Mohawk		14	14	5		33
North Central	30			14		44
Ozark	23		5		3	31
Pacific	1				6	7
Piedmont	3	18			8	29
Southern	26	8				34
Trans Texas	23		12			35
West Coast	13				7	20
Totals	179	67	37	49	35	367

Prepared by Roy & Roy

Local Service Airlines

Comparison of operating statistics years 1961 and 1962

			INCREASE 62/61 Amount	Percent
Revenue Plane Miles (000)	304 349	314,036	9 687	3
Revenue Passenger Miles (000)	1 365 789	1,627 005	261 216	19 1
Originating Passengers	6,554 433	7,710 704	1,156 271	17 6
Enplaned Passengers	6 938 467	8,119 285	1 180 818	17 0
U S Mail Ton Miles	3 355 263	3,832 241	476 978	14 2
Express and Freight Ton Miles	8 513 469	10,992,141	2 478 672	29 1
Average Passenger Load (Persons)	13 1	14 3	1 2	9
Passenger Load Factor (%)	41 8	42 5	0 7	
Total Revenue Ton Miles (000)	142 427	170 312	27 885	19
Ton Mile Utilization (%)	43 2	43 8	0 6	
Average Revenue Load (Tons)	1 36	1 49	0 13	9
Performance Factor (%)	96 9	97 1	0 2	
Revenue Hours	651 090	686 893	35,803	
Off-an Speed (mph)	160 3	166 0	5 7	3
Number of Departures	1,129 552	1,203 309	73,757	
Average Length of Hop (Miles)	92 4	94 8	2 4	
Average Length of Journey				
Originating Pax	208	211	3	
Enplaned Pax	197	200	3	1
As of Fourth Quarter				
Number of Aircraft	353	367	14	
Number of Employes	13 479	14 760	1 281	
Number of Stations	551	564	13	2

Prepared by Roy & Roy

could go higher, he said, because of the resulting diversion from local service airlines. Central Airlines asked that it be granted the third level certificate if the examiner considered such service necessary.

Now, six air taxi operators, forming the National Assn. of Third Level Airlines, seek to provide, without subsidy, scheduled service to communities which have inadequate service or none at all. The association includes Trans Air Lines, Tag Airlines, Henson Aviation, Apache Airlines and Executive Airlines. They propose "all weather service" on a scheduled basis, providing the airfield can handle IFR flights.

Certification as third level carriers would give the members a degree of official recognition which would enhance their financial standing in the industry, the association contends. In addition, the organization feels it could build higher traffic volume for the entire airline industry by serving many new, unserved points.

Many local service airline officials fear these smaller carriers might accept certification without subsidy, only to request it later.

Although the association says that its members have no particular aircraft preference, Aero Design has been the leading contender for their business. Aero has rolled out its Grand Commander, a 10-place aircraft designed for third level and air taxi use. The airplane would have a direct operating cost of 30 cents per aircraft mile with one pilot.

CAB's problems in managing subsidy payments have been complicated by the problem of local service orders for turbojet-powered BAC 111s for use on high density operations. Mohawk Airlines has ordered four of the British aircraft, which it will finance privately. CAB rejected Bonanza Air Lines' guaranteed loan application for three.

Alan S. Boyd, CAB chairman, has warned the local carriers against expansion into trunkline areas and the purchase of larger equipment to handle such routes. His stand is interpreted as an indication that the Board has no intention of permitting local service competition in trunk markets.

In a letter to Mohawk Airlines President Robert Peach, Boyd criticized the BAC 111 order as premature and fraught with substantial risks in the light of Mohawk's 10 point load factor drop to 48% after the airline switched to higher capacity Martin and Convair aircraft—this in spite of a 400% gain in revenue passenger miles. Boyd added that the CAB was putting Mohawk on notice that it will not permit subsidy to bear an added burden of operating the jet aircraft.

Replying, Peach said that there was an apparent misunderstanding since the BAC 111 purchase was intended to reduce, not increase subsidy requirements. The order was placed only after careful consideration of the risk involved and was necessary for Mohawk to remain competitive, he said.

Scheduled for delivery beginning in 1966, the twin-jet aircraft will connect several of Mohawk's larger cities with New York. Available seat mile costs on the aircraft are estimated at 2.39 cents as compared to 2.55 cents on the company's present piston engine aircraft.

Boyd's opposition to local service entry into trunk markets, his letter to Mohawk, and CAB studies on a possible replacement for the DC-3 are considered indications that, while the Board may go ahead with subsidy reductions, it will be careful to control the rate of reduction and retain a maximum amount of "grass roots" service.

Here are the rough specifications which CAB considers necessary in any DC-3 replacement:

- **Prices** including electronics, $500,000, preferably closer to $400,000.
- **Capacity for 24 passengers,** and space for 1,000 lb. of cargo.
- **Fuel capacity** to permit four intermediate stops on stage lengths of 500 mi. with no more than one refueling.
- **Runway length** requirement of no more than 4,000 ft.
- **Direct operating cost** per plane mile, including depreciation of under 60 cents for an 80-mile stage length.

An aircraft design study committee of the Assn. of Local Transport Airlines has also been working on a proposed replacement, which has these specifications:

- **Capacity of 18 passengers,** plus baggage and 1,000 lb. of cargo.
- **Maximum runway length** requirement of only 3,000 ft. and under 1,000 ft.—STOL capability—if feasible.
- **Direct operating cost** per plane mile of not more than 40 cents, based on a 5½ hr. day utilization over an average stage length of 80 mi.
- **Range** with full payload and required fuel reserves of 500 mi. with three intermediate stops.

Allegheny Airlines President Leslie O. Barnes, who is chairman of the committee, believes that development funds may be required either from the manufacturer or from a government agency.

Greatest need is for a replacement to serve the many smaller points on the local service system since the denser long haul routes are being adequately served by Martins, Convairs and F-27s, he contends. Even replacement of these aircraft with larger, more modern equipment would be desirable, he said, because profits from this level could be used to offset subsidy requirements from less productive markets.

NEWEST ADDITION to Aeroflot equipment under development is the Il 62. Powered by four rear-mounted 23,000 lb. bypass turbojet engines designed by N. D. Kuznetsov, it has capacity for 152 passengers. Configuration of the Il-62 bears considerable resemblance to British Vickers VC-10. Range of Il-62, to enter service soon, is sufficient to fly nonstop Moscow to New York, Russians claim.

Excess Capacity Tempers Aeroflot Growth;

Excess capacity is not solely a problem of capitalist airlines, Russia's Aeroflot demonstrated last year. Traffic reached another peak but fell short of planning goals, and empty seats multiplied at an unprecedented rate.

Furthermore, the state owned and operated carrier ran into other problems, capitalist and noncapitalist style. Delays were met in introducing the new Tu-124 turbofan and An-24 turboprop transports. There were complaints over concentration on supersonic transports or on big, long haul transports at the expense of turbine-powered short-haul transport development. And unusually bad summer weather at key cities forced many flight cancellations at normally heavy traffic periods.

Excess airline capacity, like any surfeit of consumer goods or services is a rare phenomenon in the USSR. The Communist carrier attempted to meet this unfamiliar situation with un-Marxist remedies: more advertising and promotion, and wholesale price cutting.

Continued lowering of passenger fares, which are already equal to or below railroad tariffs on many routes has put Aeroflot in a profit squeeze. As recently as 1959, when Aeroflot was little concerned about empty seats, what the carrier described as transportation profit was only about 1.4%.

Aeroflut has grown enormously since 1959, permitting substantial economies through increased traffic volume. But along with a 130% increase in the "amount of transportation performed" in the 1959-1962 period, there was an 80% jump in capital investment and the steadily eroding rate structure.

S. Kosobreyev, identified as a senior expert in the USSR's State Economic Council, has clearly indicated that Aeroflot is encountering difficulties in providing a return on its mushrooming capital investment. His recent article in the Russian airline's official house organ Grazhdanskaya Aviatsiya was titled "Bigness Still Doesn't Mean Profitableness."

Aeroflot undoubtedly had bigness as it marked its 40th anniversary on Feb. 9, 1963. In celebrating the event, Soviet publications boasted time and again that Aeroflot is the largest airline in the world from almost every standpoint.

Last year the carrier handled about 27 million passengers, compared with 21.8 million in 1961, 16 million in 1960, and 12.2 million in 1959. But Aeroflot missed its 1962 goal of 30 million passengers by a wide margin.

During the first half of 1962, Aeroflot carried 29% more passengers and 9% more cargo than in the same 1961 period. Even so, it fell slightly short of its passenger quota and met its cargo tonnage goal by only 88%.

Frequency of Aeroflot flights between Russia's largest cities last year remained low by American standards—a maximum of 15-20 roundtrips daily.

Aeroflot concedes that some of its personnel believe traffic goals for 1962 and following years were set too high. Nevertheless, carrier officials remain optimistic that long-range traffic targets will be achieved.

Last summer, Aeroflot claimed it handled 120,000-150,000 passengers daily during peak traffic periods. A rate of 150,000 daily, if maintained, would equal nearly 55 million passengers annually.

Less than a year before, in the fall of 1961, Premier Khrushchev placed Aeroflot's maximum daily capacity at 100,000 passengers.

More than half of Russia's long-distance passengers moving along main travel routes now go by air, according to Grazhdanskaya Aviatsiya. This total is expected to reach 80% in the next few years.

Aeroflot's targets for 1963 are 35 million passengers and a 33.5% increase in ton-miles flown as compared to 1962.

The passenger goal indicates a slackening in Aeroflot's rate of traffic growth.

RANGE OF AEROFLOT'S existing and soon-to-be introduced turbine and piston engine equipment is evident from this ramp display. Included is the turbofan powered Tu-124 (center, upper row), and its size is indicated by the Tu-104 to the left and Il-18 (right). Long-range Tu-114 is parked in background (top, left). In foreground (from left) are the An-10A, An-14, An-24 and Mi-4 helicopter.

Traffic Falls Short of Goal

However, the Soviet pace is still much faster than the airline growth rate in the United States and other Western nations with highly developed air transportation systems.

Premier Khrushchev reported that the Soviet Union topped its target for air passenger traffic during the first four years of the current Seven-Year Plan (1959-1965) despite the unfulfilled 1962 quotas.

Aeroflot still hopes to carry 50 million passengers annually in 1965, last year of the Seven-Year Plan. This would require increases of about 7.5 million passengers annually in both 1964 and 1965, assuming that this year's target of 35 million passengers is reached.

1980 Traffic Goal

Traffic goal for 1980 is 200 million passengers annually. By that time Aeroflot hopes to handle up to a million passengers daily during peak traffic periods and to be serving about 4,000 cities and towns in the USSR.

As it reached its 40th anniversary, Aeroflot said that it has 248,400 mi. of domestic routes and over 62,100 mi. outside the USSR.

By early 1963 Aeroflot was flying to 29 foreign capitals. Most important new service is the 6,769-mi. run between Moscow and Havana, which was inaugurated in January with four turbuprop, 170-passenger, Tupolev Tu-114s. Direct airline agreements recently signed by the Soviet Union with Iraq and Syria authorize two more international services for Aeroflot: Moscow-Baghdad and Moscow-Damascus. Twenty-one foreign airlines now fly into the USSR.

Aeroflot's hopes for entry into the United States, Japan and Brazil did not materialize during 1962. But the Soviet carrier continued its penetration of Africa.

Four-turboprop Ilyushin Il-18s are now flying from Moscow to Accra, Ghana via Belgrade, Yugoslavia, Rabat, Morocco and Conakry, Republic of Guinea. The 6,586-mi. run is covered in 20 hr. In June, Aeroflot inaugurated weekly Il-18 service from Moscow to Khartoum, the Sudan, via Cairo.

Tu-114s last July surveyed a Moscow-Havana route via Belgrade and Conakry, where a large new airport has been completed with Soviet aid. However, Aeroflot decided to make its first regular Moscow-Havana flights nonstop via the North Atlantic instead of via Conakry and the South Atlantic.

In publicizing its new foreign routes, Aeroflot disclosed that its long-range plans call for a much larger percentage growth for international passenger traffic than for domestic business.

The Russian carrier expects to fly 80-90 times as many passenger-miles in 1980 as in 1960 on international routes and to serve most of the capitals and large cities of the world. Domestic passenger miles, while showing a far larger absolute growth in the 1960-1980 period, are expected to increase only 18-20 times.

The 182-passenger Ilyushin Il-62, which was first unveiled to the public last September, is expected to play a major role in expanding Aeroflot's long-haul international services.

Powered by four aft-mounted 23,000-lb.-thrust turbofan engines designed by N. D. Kuznetsov, the 168-ft.-long Il-62 will be able to cruise nonstop from Moscow to New York at 560 mph. with standard fuel reserves. The Il-62 may also be used for flights from Moscow to India, Indonesia and Australia, to Africa and to South America, and for the trans-Siberian run to Vladivostok and Japan.

Il-62 Service

Aeroflot Chief Yevgeny Loginov said last December that the time is not far off when the Il-62 will go into transcontinental service. However, on the basis of the time required to put other new Soviet transports in regular service, the Il-62 may not start scheduled operations until 1964 or 1965.

Russian government and aviation authorities continue to assert that the USSR will have the first supersonic and hypersonic commercial transports.

Designer V. M. Miasishchev declared last year that the cruising speed of jet passenger planes will approach 1,242 mph. before 1970.

Outlining his views on supersonic, hy-

persome VTOL and STOL transports that the Soviet Union must build, test and make available for use in the 1970s and 1980s, Mesishchev declared that "it is already possible to say that by 1980 passenger transports will fly 1,552-1,863 mph."

Writing in the Russian magazine Aviation and Cosmonautics, Soviet Designer A. I. Mikoyan said that hypersonic flight with variable-wing aircraft will come in the not too-distant future and will eventually prove dependable, cheap and simple. Soviet science and technology, he said, have every capabilities of being first in the field of hypersonic commercial aviation.

Some Criticism

While Russian aircraft designers were peering 10-20 years into the future, Aeroflot officials took some critical looks at existing problems. Concern was expressed that too much emphasis was being placed on developing supersonic aircraft—and even on conventional long-haul jets such as the Il-62—at a time when people are complaining about the inadequacy of short- and medium-range services.

Shortly after the Il-62 roll-out, M. Knrokov, deputy chief of Aeroflot's Far Eastern Territorial Administration based at Khabarovsk, declared that what his area needs most is a turbine-powered aircraft in the 33,000-55,000-lb gross weight category which has substantial freight carrying capacity and can operate from short unpaved runways. The Il-62, by contrast, is believed to gross well over 300,000 lb.

Weather a Problem

Domestically, Aeroflot had major operating headaches during 1962, stemming from two factors: miserable weather conditions in Russia's populous central area most of the summer, which especially hampered twin-jet Tu-104 flights; and failure to get its new Tu-124 and An-24 medium-range transports in scheduled service until November.

Persistent rain and cold, which combined to give central Russia its worst summer weather in more than a decade, resulted in wholesale delays and cancellations of flights at Moscow, Leningrad and other major cities. Scheduled airline operations at some of Aeroflot's smaller central area cities that still lack paved runways were washed out for days.

Repeated postponements in placing the twin-turbofan Tupolev Tu-124 and twin turboprop Antonov An-24 into service caused a severe financial drain. Both of these 44-passenger aircraft were first exhibited in the spring of 1960 and were originally slated to go into regular service during 1961.

Aeroflot expects to place An-24s and Tu-124s in regular service on about 50 routes during 1963. With their help, the Russian carrier estimates it will carry almost 75% of its passengers in turbine-powered transports this year, compared with a goal of 68% in 1962, when jet or turboprop aircraft were flying 120 Soviet routes.

Plans for a new version of the Tu-124 have been revealed. This Tu-124A will have Caravelle-style, aft-mounted engines and may accommodate as many as 70 passengers.

A 100-passenger modification of the twin-jet, 70-passenger Tu-104A was also disclosed. It has the same capacity as the Tu-104B, which was put in scheduled service early in 1959. But the 100-passenger Tu-104A has the same fuselage as the standard Tu-104A and Tu-104, while the Tu-104B's fuselage is stretched 47 in.

Aeroflot said it could obtain the equivalent of a 44% increase in its Tu-104A fleet and save millions of rubles by relatively small outlays for the 100-passenger modification.

The need for economy is being increasingly emphasized by Aeroflot's management. There is outspoken criticism of the continued proliferation of glamor-type transports for the most important Soviet routes while regional administrations are still forced to operate with equipment unsuited to local conditions.

The increasing diversity of Aeroflot's fleet has placed a heavy burden on the carrier's maintenance and overhaul facilities, which are insufficiently specialized and often operate on a single-shift basis.

Soviet reports also speak of serious shortcomings in organizing the utilization of Aeroflot's labor resources.

Aeroflot's total capital investment increased six-fold from 1950 to 1960. It is slated to quintuple in the 1960-1980 period.

Between 1963 and 1965, more than 50% of Aeroflot's capital investment is earmarked for acquisition of aircraft and helicopter types which were not in commercial service in mid-1962. By 1965, 73% of the carrier's total capital investment will be in aircraft, compared to 63% in 1959.

Russian economists see the need for stricter supervision of this big new financial outlay. They want the money used in a manner that will permit the government to reduce significantly the period required to recoup its capital investment in commercial aviation.

Much of the investment made in Aeroflot during the past several years has not had time to take effect fully. But by 1965, Aeroflot's labor productivity, aided by this investment, is expected to rise 110%. Unit transportation expense is slated to decrease 40% as compared to 1960.

Plans call for revenue plane hours flown per jet plane in regular service to

Aeroflot Growth—1940 to 1962

	1940	1958	1959	1960	1961	1962
Rate of growth of unduplicated air route mileage (in percentage, with 1940 equalling 100%)	100	243	247	250	253	
Passengers carried (in millions)	0.4	8.2	12.2	16.6	21.8	27 (estimated)
Passenger-kilometers (billions)	0.2	6.4	9.1	12.1	16.4	
Mail (thousands of metric tons)	14.3	87.8	97.9	130.7	195.6	
Cargo (thousands of metric tons)	44.1	357.8	446.4	545.8	647.3	
Cargo (millions of ton-kilometers including mail)	23.2	399.4	438.6	562.8	801.8	

Source: "USSR in Figures— 1961" (published May, 1962)

AEROFLOT Mi-4 HELICOPTER service departs from a heliport in Lenin Square in the city center of Baku to the airport of a new industrial center of Sumgait, 10 mi. to the north.

NEW AEROFLOT TERMINAL at Dushanbe, capital of the Tadzhik Soviet Republic, is shown with Il-18 parked in front. Dushanbe is close to the Afghanistan border. The terminal, one of several completed last year by Soviets, is described as air conditioned.

increase almost 50% during the 1962-1965 period. Currently, under utilization of equipment is one of Aeroflot's most critical problems, just as it was in 1959.

Aeroflot said recently that an analysis of aircraft utilization clearly shows that the transport fleet has been inadequately employed during the past three years. Revenue hours flown by Tu-114s, Tu-104s, Il-18s and An-10s in the 1959-1961 period were low and showed little annual improvement.

"Average daily utilization for jet [including turboprop] planes has been 3-4 hours," the report said. "For various reasons, equipment has stood idle the rest of the time. It doesn't make sense economically to use expensive aircraft less than half as much as they are capable of being employed."

While the bulk of Aeroflot's capital investment continues to be used for new transports, the Russian carrier is not neglecting ground facilities.

Last year new airport terminals were opened at Odessa, Sukhumi, Ashkhabad, Kemerovo, Tobolsk and other cities. Aeroflot plans to start regular service from Moscow's new Domodedovo Airport this spring or summer.

Located about 25 mi. south of Moscow, Domodedovo will be Russia's largest commercial airfield. Its terminal will have a capacity of "several thousand passengers per hour"—considerably more than Moscow's three existing airports are now able to handle together.

Covered passageways will extend from each end of Domodedovo's 1,300-ft.-long glass, aluminum and concrete terminal building toward the field. From these two passageways—each able to serve six aircraft simultaneously—passengers will board their planes via horizontal ramps. Domodedovo's five-story, 500-bed airport hotel has already been completed.

Both Domodedovo and Kiev's large new Borispol Airport, already in operation but still incomplete, are intended to be showpieces for foreign travelers entering the Soviet Union.

Aeroflot admits, however, that planning errors have hampered its airport construction program. The new international class Tolmachevo Airport near Novosibirsk was, for example, built without due consideration to future traffic growth.

Russian civil aviation officials have stated that blueprints and budgets for new airport projects have had to be reexamined frequently in recent years. As a result, cost estimates have soared 50-150% in some cases.

Aeroflot has warned that dispersion of materials and funds on too many airport projects at once must stop, adding: "We should concentrate on the most important projects and on those already under way."

Boeing 727 short-medium haul transport, powered by three Pratt & Whitney JT8D turbofan engines, undergoes final checkout on ramp at Renton, Wash.

Specifications

U.S. Military Aircraft

Primary mission	DOD designation	Manufacturer	Popular name	Old designation	Service	No. in crew	Wingspan, ft.	Max. length, ft.	Max. height, ft.	Wing area, sq. ft.	Empty weight, lb.	Gross weight, lb.	
Attack	A-1J	Douglas	Skyraider	AD-7	Navy	1	50 5	38 9	15 0	400	10 550	18 000	1 Wr R3350-2
	A-3B	Douglas	Skywarrior	A3D-2	Navy	3	72 5	74 3	22 8	680	39 400	70 000	2 P&W J57-P
	A-4E	Douglas	Skyhawk	A4D-5	Navy	1	27 5	41 3	15 0	260	9 284	15 500	1 P&W J52-P
	A-5C	NAA/Columbus	Vigilante	A3J-3	Navy	2	53 0	73 0	20 0	700			2 GE J79-GE
	A-6A	Grumman	Intruder	A2F-1	Navy	2	53 0	54 8	15 8			43 000	2 P&W J52-P
Bomber	B-26C	Douglas	Invader	B-26C	USAF	4	70 0	50 8	18 8	540		35 000	2 P&W R2800
	B-47E	Boeing	Stratojet	B-47E	USAF	3	116 0	107 0	28 0			200 000	6 GE J47-GE
	B-52F	Boeing	Stratofortress	B-52F	USAF	6	185 0	152 8	48 3	4 000		450 000	8 P&W J57-P
	B-52G	Boeing	Stratofortress	B-52G	USAF	6	185 0	157 5	40 8	4 000		488 000	8 P&W J57-P
	B-52H	Boeing	Stratofortress	B-52H	USAF	6	185 0	157 5	40 8	4 000		488 000	8 P&W TF33-
	RB-57D	Martin	Canberra	B-57B	USAF	1	64 0	65 5	15 5	960		50 000	2 Wr R5-4
	B-58A	GD/Ft. Worth	Hustler	B-58A	USAF	3	90 8	96 8	29 0	1 542		160 000	1 GE J79-GE
	B-66D	Douglas	Destroyer	B-66D	USAF	3	72 8	75 2	23 8	780	42 788	78 000	2 All J71-A-11
	B-70	NAA/Los Angeles	Valkyrie	XB-70	USAF	4						600 000	6 GE J93-GE
Fighters	F-84F	Republic	Thunderstreak	F-84F	USAF	1	33 5	43 3	14 3			25 000	1 Wr J65 W-3
	F-100D	NAA/Los Angeles	Supersabre	F-100D	USAF	1	38 6	47 0	16 0	385		28 000	1 P&W J57-P
	F-101B	McDonnell	Voodoo	F-101A	USAF	2	39 7	67 4	18 0			50 000	2 P&W J57-P
	F-101C	McDonnell	Voodoo	F-101C	USAF	1	39 7	67 4	18 0			48 000	2 P&W J57-P
	F-102A	GD/Convair	Delta Dagger	F-102A	USAF	1	38 1	68 3	21 2	661		27 000	1 P&W J57-P
	F-104C	Lockheed/Calif.	Starfighter	F-104C	USAF	1	21 9	54 8	13 5	196		21 000	1 GE J79-GE
	F-105D	Republic	Thunderchief	F-105D	USAF	1	34 9	64 3	19 7	386	28 000	54 000	1 P&W J75-P
	F-106A	GD/Convair	Delta Dart	F-106A	USAF	1	38 3	70 8	20 3	631		35 000	1 P&W J75 P
	F-111A	GD/Ft. Worth		TFX	USAF	2						90 000	2 P&W TF30
	F-111B	Grumman		TFX	Navy	2						85 000	2 P&W TF30
	AF-1E	NAA/Los Angeles	Fury	FJ-4B	Navy	1	39 1	36 0	13 0	338		19 000	1 Wr J65-W 16
	F-3C	McDonnell	Demon	F3H-2N	Navy	1	35 5	58 0	14 0	3001		33 000	
	F-4B	McDonnell	Phantom 2	F4H-1	Navy	2	38 4	55 0	16 3	530		40 000	1 AB J71-A-2
	F-4C	McDonnell		F-110A	USAF	2	38 4	55 0	16 3	530		40 000	2 GE J79-GE
	F-5B	Northrop	Freedom Fighter	N-156F	USAF	2	26 0	46 3	13 1	174	8 147	12 282	2 GE J85-GE
	F-8A	Douglas	Skyray	F4D-1	Navy	1	33 5	45 4	13 0	357		21 000	1 P&W J57-P
	F-8E	LTV/Chance Vought	Crusader	F8U-2NE	Navy	1	35 7	54 5	15 8	3501			1 P&W J57-P
	F-9J	Grumman	Panther	F9F-8	Navy	1	34 5	41 8	12 3			20 600	1 P&W J48-P
	F-11A	Grumman	Tiger	F11F-1	Navy	1	31 7	46 0	12 0	250	13 438	21 174	1 Wr J65-W 16
Observation	O-1E	Cessna	Bird Dog	L-19E	Army	2	36 0	28 0	7 3	174	1 814	2 400	1 Con O-470-11
	OV-1C	Grumman	Mohawk	AO-1	Army	2	42 0	41 0	12 7	330	9 205	11 079	2 Lyc T53 L-3
Patrol	P-2H	Lockheed	Neptune	P2V-7	Navy	7	101 3	81 7	29 3	1 000	40 358	78 336	2 Wr R3350-32
	P-3A	Lockheed	Orion	P3V-1	Navy	10	99 0	104 5	33 8	1 300		135 000	4 All T56-A-10
	P-5B	Martin	Marlin	P5M-2	Navy	7	118 2	101 8	33 0	1 406	46 480	74 442	2 Wr R3350-32
Anti-sub	S-2D	Grumman	Tracker	S2F-3	Navy	4	72 6	43 6	16 8	490	18 315	29 147	2 Wr R1820-82
Early warning	E-1B	Grumman	Tracer	WF-2	Navy	4	99 7	45 3	18 8	807	21 024	37 000	2 Wr R1820 re
	E-2A	Grumman	Hawkeye	W2F-1	Navy	5	80 0	55 3	18 4	700		40 070	2 All T56-A-8
Cargo/transport	C-97D	Curtiss-Wright	Commando	C-46D	USAF	4	108 1	76 3	21 8	1 360	26 000	45 000	2 P&W R2800-
	C-47E	Douglas	Skytrain	C-47E	USAF	3	95 0	64 5	16 0	987	16 500	26 000	2 P&W R1830
	C-54	Douglas	Skymaster	C-54	USAF	5	117 6	93 6	27 5		40 000	73 000	4 P&W R2000
	C-97D	Boeing	Stratofreighter	C-97D	USAF	5	141 3	110 2	38 3	1 706	85 400	153 000	4 P&W R4360
	C-117D	Douglas		R4D-8	Navy	3	90 0	67 8	19 3	669	18 000	31 000	2 Wr R1820-80
	C-118A	Douglas	Liftmaster	C-118A	USAF	5	117 6	108 6	28 7	1 463	84 000	100 000	4 P&W R2000-
	C-119J	Fairchild	Flying Boxcar	C-119J	USAF	6	109 3	86 6	25 3	1 447	39 700	91 000	2 Wr R3350-32
	C-121G	Lockheed	Super Constellation	C-121G	USAF	6	126 0	116 2	30 0			120 000	4 Wr R3350-34
	C-123B	Fairchild	Provider	C-123B	USAF	4	110 0	76 3	34 1	1 223	31 000	54 000	2 P&W R2800-
	C-124C	Douglas	Globemaster 2	C-124C	USAF	6	173 3	130 0	48 3	2 510	100 000	175 000	4 P&W R4360-
	C-130B	Lockheed/Georgia	Hercules	C-130B	USAF	4	132 6	97 8	38 0	1 746	67 200	135 000	4 All T56-A 7
	C-130E	Lockheed/Georgia	Hercules	C-130E	USAF	5	132 6	97 8	38 0	1 746	70 270	155 000	4 All T56-A 7
	C-131F	GD/Convair	Samaritan	C-131F	USAF	2	91 6	74 7	27 3	817	30 000	44 000	2 P&W R2800-
	C-133B	Douglas	Cargomaster	C-133B	USAF	6	179 7	158 0	48 6			300 000	4 P&W T34-P
	C-135B	Boeing	Stratoliner	C-135B	USAF	4	130 8	134 5	38 4	2 400		270 000	4 P&W TF33-P
	VC-137C	Boeing		VC-137C	USAF	4	148 6	152 9	42 5	2 892	120 164	312 000	4 P&W TF33-P
	C-140A	Lockheed/Georgia	Jetstar	C-140A	USAF	5	54 4	60 4	20 4	543	21 455	40 021	4 P&W J60-P-3
	C-141A	Lockheed/Georgia	Starlifter	C-141A	USAF	4	160 0	145 0	39 3	3 228	133 000	316 000	4 P&W TF33
	XC-142A	LTV/Hiller/Ryan		XC-142A	USAF	2	67 0	58 1	26 1	534		87 474	4 DE T64-GE
	C-1A	Grumman	Trader	TF-1	Navy	2	72 6	43 5	16 1	490		27 000	2 Wr R1820-82
	C-2A	Grumman		C-2A	Navy	2	80 6	56 0	15 7	700			4 All T56-A-8
Training	T-1A	Lockheed		T2V-1	Navy	2	42 0	38 0	17 0			10 800	1 All J33 A 22
	T-2A	NAA/Columbus	Buckeye	T2J-1	Navy	2	36 0	38 7	14 8	255			1 Wa J34 WE-
	T-28B	NAA		T-28B	USAF	2	40 7	32 0	12 7	255	8 700	7 900	1 Wr R1820-9H
	T-29D	GD/Convair		T-29D	USAF	2	91 6	74 7	27 3	817		44 000	2 P&W R2800-
	T-33B	Lockheed		T-33B	USAF	2	38 9	37 8	11 7	237	8 000	12 200	1 All J33 A-35
	T-34B	Beech	Mentor	T-34B	Navy	2	32 8	25 8	8 0	179	2 600	2 800	1 Con O-470 11
	T-37B	Cessna		T-37B	USAF	2	33 8	29 3	9 2	184	4 056	6 00	2 Con J69 T-25
	T-38A	Northrop	Talon	T-38A	USAF	2	25 3	46 3	12 8	170	7 340	11 700	2 GE J85-GE-2
	T-39D	NAA	Sabreliner	T-39D	USAF	2	44 4	43 7	16 0	342	10 200	17 700	2 P&W J60-P-3
	T-40A			T-40A	USAF								
	TF-9J	Grumman	Panther	F9F-8T	Navy	2	34 5	48 5	12 1			20 600	1 P&W J48 P-8
Utility	U-1A	DH/Canada	Otter		Army	2	58 0	41 8	15 0	378	4 431	8 000	1 P&W R1340-
	U-2A	Lockheed		U-2A	USAF	1	80 0	49 0	13 0			17 000	1 P&W J75-P 1
	U-3B	Cessna		U-3B	USAF	2	35 8	28 5	9 0	175	3 300	4 600	2 Con IO-470 D
	U-11B	Aero Commander		U-4B	USAF	1	40 5	35 1	14 5	285	4 800	8 000	2 Lyc IGSO 51
	U-3A	Hrbn			USAF	1	41 0	30 3	9 8	242			2 Lyc O-340 re
	U-6A	DH/Canada	Beaver	L-20	Army	1	48 0	30 3	10 6	250	2 000	5 100	1 P&W R985 re
	L-18A	Piper		L-21	USAF	2	35 2	22 8	6 9	178	930	1 750	1 Lyc O-320 re
	L-23F	Beech	Seminole	L-23F	Army	0	45 8	33 3	14 1	277	4 710	7 700	2 Lyc IO-48
	L-26C	Aero Commander		L-26C	Army	1	13 9	35 1	14 8	255	4 800	8 000	2 Lyc IGSO 54
	U-10A	Hrbn	Courier	L-28A	USAF	1	39 0	30 0	8 8	231	2 037	4 000	2 Lyc IO-540 r
	U-11A	Piper	Aztec	UO-1	Navy	1	37 0	30 1	10 3	207	2 900	4 800	2 Lyc O 540 re
	HU-16E	Grumman	Albatross	UF-2G	Navy	2	80 0	62 2	24 3	833	21 000	34 000	2 Wr R1820 T0
	CL-28	DH/Canada	Caribou 1	AC-1A	Army	2	95 7	72 0	31 8	912	17 630	28 500	2 P&W R2000
	CV-7A	DH/Canada	Caribou 3	AC-2	Army	2							0 DE T64-GE

WERPLANT	PERFORMANCE	LOADING	REMARKS
lumber and esignation	Typical for primary mission	Typical for primary mission	Superscript 1 = Estimated
6WB re. 10 tj. 9A tj. e tj. 6 tj.	Max. speed 350 mph.[1] 500 mph. class 650-mph. class Mach 2 class Mach-0.9 class	Various external stores Various internal stores 8,000 lb. stores, 2 x 20-mm Nuclear & conv. bombs 18 000 lb. external stores	Also A-1E, SA-1E, EA-1F, A-1G & A-1H versions; prototype first flew March 1945. Also A-3A, EA-3A, YRA-3B, RA-3B & TA-3B versions. Also A-4A, YA-4B, A-4B, YA-4C & A-4C (was A-4D-2N) versions. All-weather tactical reconnaissance aircraft; BLC, rearward bomb ejection; also A-5A attack version Also ECM version ordered.
70 re. 25 tj. rW tj. W tj. B-3 tj. tj. 5 tj. tj. 6 tj.	Max. speed 355 mph 600 mph. at 40,000 ft. 600 mph. at 50,000 ft. 600 mph. at 50,000 ft. 650 mph. at 40,000 ft. Max. speed 600 mph.[1] Subsonic cruise; Mach-2 dash 600-mph. class Mach-3 class	Bombs & machine guns 20,000 lb. bomb load 75,000 lb. bomb load 2 GAM-77 bombs & GAM-72 2 GAM-77 bombs & GAM-72 8-50-cal. mg., bombs Nuclear & conv. bombs in pod Various internal stores	Used by USAF Air Commando units; also in counter insurgency operations. Being phased out of USAF active inventory. Final development version of basic B-52A airframe; also B-52B, C, D & E models. Airframe partially redesigned; integral fuel tanks added to wings. Production ended Oct. 1962; turbofan engines for improved performance Similar to English Electric Canberra series. Also TB-58A trainer version Also RB-66A, RB-66B, RB-66C & WB-66D versions.
tj 91 tj. 55 tj. 13 tj. 31 tj. 7 tj.	Mach-0.9 class Mach 1.2 class Max. speed 1,000 mph.+ Max. speed 1,000 mph.+ Mach 1.2 class Mach-2 class	Various external stores 4 M-39 cannon; ext. stores 2 M-1 & 2 GAR-2A Various external stores 1 GAR-11 & 3 GAR-2A 1 T-171 Vulcan; 2 AAM-N-7	Also RF-84F; both also in service with many NATO countries. Also F-100A, C, DF-100C & F-100F two-seater. Hughes MG-13 armament control system; also TF-101B trainer version. Also RF-101C reconnaissance aircraft; both strengthened for low-altitude work. Hughes MG-10 armament control system; also TF-102A (two-seat trainer conversion) Also F-104A, B, D, G (for Germany and NATO), & J (for Japan); also TF-104G & TF-104J
38W tj. 17 tj. tj. tj. A tj. tj. 4 tj. 13 tj. 8 tj. 20 tj. 9 tj. tj.	Mach-2 class Mach-2 class Supersonic at sea level Supersonic at sea level Mach speed 687 mph. Transonic speed Max. speed 1,400 mph.+ Max. speed 1,400 mph.+ Mach 1.3 class Mach-0.9 class Mach 1.8 class Transonic speed Mach-1.2 class	13,000 lbs. of bombs 1 MB-1, 2 GAR-3A & 2 GAR-4A Various stores Hughes missile system 4-20 mm. cannon; AAM-N-7 4-20 mm. cannon; ext. stores 4-6 AAM-N-6A, 4 AAM-N-7 4-8 AAM-N-6A, 4 AAM-N-7 Varied up to 8,500 lb. load 4 20 mm. cannon; ext. stores 4-20 mm. cannon; 4 AAM-N-7 4-20 mm. cannon; bombs 4-20 mm. cannon	All weather fighter bomber; also F-105F as two-seat modification Hughes MA-1 armament control system Variable-sweep wing; STOL capability Variable-sweep wing; STOL capability Fighter-bomber Also MF-3E armed with 4 AAM-N-3 missiles. In service with nine USN and two USMC squadrons; first unit delivered to USAF Feb. 4, 1963. Del. verse scheduled for 1963. Fighter trainer des. by DOD for MAP nations. Prototype flew Jan. 1651. Also FSC-1T two-seat trainer modification Also AF-9J & TF-9J versions.
re tp.	Max. speed 115 mph Max. speed 325 mph.[2]	Pilot and observer Pilot and observer	Returned to production for U.S. Army Feb. 62 STOL performance
W re. plus 2 We J34 tj. W tp. W re	Max. speed 345 mph. Max. speed 450 mph.+ Max. speed 285 mph.[2]	Torpedoes, depth charges, bombs 4 torpedoes, 8 1,000 lb. bombs	Also used by NATO. Design based on Lockheed Electra comm. transport Flying boat
re.	Max. speed 275 mph.[1]	Sonobuoys, depth charges, torpedoes	Also S-2A, TS-2A, S-2B, S-2C & RS-2C; in service with Brazilian, Canadian, Dutch, Italian & Japanese navies.
p.	Max. speed 285 mph.[1] Max. speed 400 mph.[1]	Hazeltine APS-82 early warn. sys. Airborne tac. data system (ATDS)	For airborne early warning and fighter direction Linked to Naval tac. data system (NTDS) for command and control
51 re. re	Cruise 230 mph. at 10,000 ft. Cruise 160 mph.	50 troops or 10,000 lb. 28 troops or 7,000 lb.	Used by 1st Air Commando group for counter insurgency work Used also by USN (designation was R4D-5, -6, 7); also in EC, RC, LC, RC, SC, TC and VC versions.
9 re.	Cruise 260 mph. at 14,000 ft.	80 troops or 32,000 lb.	Used also by USN & USCG (was R5D series); also in EC, 11C, RC, SC, TC and VC versions.
50 re. re	Cruise 300 mph. Cruise 250 mph. at 15 000 ft	60 troops or 45,000 lb. 28 passengers	Also C-97A and C, KC-97F & G tankers and VC-97D Equivalent to Douglas Super DC-3; about 100 in service; also C-117A, B, C, LC-117D, VC-117A, B & D
CB17 re	Cruise 315 mph. at 23 000 ft.	76 troops or 25,000 lb.	Equivalent to Douglas DC-6A; also used by Navy (was R6D series); also C-118B; VC-118A and VC-118B
W re. re.	Cruise 250 mph. at 18 000 ft. Cruise 335 mph.	62 troops or 30 000 lb. 106 passengers or 40 000 lb.	Used also by USN, USMC & NATO forces; also C-110C, F & G versions. Similar to Lockheed Model 1049; used also by Navy; also C-121A, C and J; also EC, RC, TC, VC, WC versions. Also YC-123H STOL modification.
03W re. 03A re. p.	Cruise 160 mph. at 5,000 ft. Cruise 265 mph. Cruise 350 mph., 1,950 nmi	60 troops or 24,000 lb. 200 troops or 74,000 lb. 92 troops or 35,600 lb.	Also C-121A. Also C-130A, RC-130A, JC-130B, HC-130G (Navy & USCG), C-130D, LC-130F (Navy), KC-130F (Navy), C-130F. Long range version of basic C-130 series Also used by Navy (was R4Y series); carries 27 litters; also C-131A, E and G (Navy), and VC-131A.
p. 90W re.	Cruise 340 mph., 3,350 nmi Cruise 285 mph. at 20 000 ft.	92 troops or 35 000 lb. 40 passengers or 12,000 lb.	Also C-131A. Also C-135A and KC-135A with P & W J57-P-59W tj.
0W tp. 5 tj. 5 tj. tj	More than 100 000 lb. Cruise 530 mph. at 35 000 ft. Mach 0.84 at 35 000 ft Cruise 525 mph., 2,250 nmi	120 troops VIP Instrumentation	Presidential transport; also VC-137A with P & W J57-P-59W tj. For evaluation of traffic control & on vards with AFCS; also VC-140 B for special missions.
97 tj. tj. tp. re p.	Cruise 505 mph., 3,710 nmi VTOL 250-kt. cruise cruise Cruise 250 mph Cruise 425 mph.	154 troops or 93,000 lb. 32 troops on 8,000 lb. 15 000 lb.	Formerly called Tri-Service Transport. Conversion of Grumman S-2D design Based on E-2A design, but with new fuselage.
tj 8 tj. D re.	600 mph. class Max. speed 402 mph. at 20 000 ft. Max. speed 350 mph.	Instructor and student Mg., rockets, bombs Instructor and student	Developed from Lockheed T-33 series. Also T-2B powered by P & W J60 F-3A tj. Also T-2BA, YAT-28E with Lyc. T55 under development for counter-insurgency work
97 re. tj re. tj. tj tj	Cruise 230 mph. Max. speed 380 mph. Max. speed 190 mph. Max. speed 408 mph. Mach 1.2 class Max. speed 540 mph.	14 students 2-50-cal. mg. Instructor and pilot 2 gen'l. purpose arm. pods Instructor and pilot 3 students	Trainer for bombardiers and navigators. Also used by Navy. Also used by USAF (T-34A) Canada, Chile, Colombia & Japan. Counter-insurgency/light fuel tanks, miscellaneous armament Training in supersonic flight, navigation, aerobatics, night flying Tactical radar trainer, equivalent to NAA Sabreliner Model NA265.
A tj	Transonic speed	2 20-mm. cannon	Based on Grumman F-9J (was F9F-8)
2H2-G re 3 tj re re	Max. speed 153 mph Extreme altitude capability Max. speed 233 mph Cruise 244 mph. at 10 000 ft.	9-11 passengers Varied Pilot & 5 passengers 7 passengers 8 passengers	High-altitude reconnaissance and research Equivalent to Cessna 310 series; supported by Cessna field representatives. Equivalent to Aero Commander 680 F; also U-4A (Model 950A) STOL performance.
-A1A0 re* 0 re e	Max. speed 103 mph Max. speed 130 mph Max. speed 235 mph. Cruise 244 mph. at 10,000 ft. Max. speed 180 mph Max. speed 215 mph. Max. speed 225 mph.	Pilot and 7 passengers Pilot and one passenger Pilot or pilot 7 passengers 7 passengers 5-7 passengers 5 passengers 10 passengers+rescue equip.	Equivalent to Piper Super Cub 150 Equivalent to Beech Queen Air 65 Equivalent to Aero Commander 680F; also U-6B & RU-9D (Model 360A). Equivalent to Piper commercial Aztec; model PA-23-250. Search and rescue.
W re. M2 re. to.	STOL performance STOL performance	32 troops or 8,020 lb.	

U. S. Missiles

Mission category	Name	Designation	Cognizant service	System manager or prime contractor	STATUS: Research	STATUS: Development	STATUS: Production	STATUS: Service use	AIR FRAME: Associate contractor or manufacturer	Maximum length, ft.	Max. span wings or fins, ft.	Body diameter, ft.	Launch weight, lb.
Air-to-air	Falcon	GAR-1D	USAF	Hughes			✓	✓	Hughes	6 5	1 7	0 53	120
	Falcon	GAR-2A	USAF	Hughes			✓	✓	Hughes	6 5	1 7	0 53	120
	Super Falcon	GAR-3A	USAF	Hughes			✓	✓	Hughes	7 2	2 0	0 55	150
	Super Falcon	GAR-4A	USAF	Hughes			✓	✓	Hughes	6 7	2 0	0 55	145
	Falcon	GAR-9	USAF	Hughes	✓	✓			Hughes				
	Falcon	GAR-11	USAF	Hughes			✓	✓	Hughes	7 0		0 39	300
	Genie	MB-1	USAF	Douglas			✓	✓	Douglas	9 0	3 3	1 5	835
	Sidewinder 1A	AAM-N-7	USN	Philco			✓	✓		9 0		0 42	150
	Sidewinder 1C		USN	Philco		✓	✓						
	Sparrow 3A	AAM-N-6 -6a	USN	Raytheon		✓	✓	✓	Raytheon	12 0	3 3	0 67	100
	Sparrow 3B	AAM-N-6b	USN	Raytheon		✓	✓		Raytheon	12 0	3 3	0 67	100
Air-to-surface	Bullpup A	ASM-N-7a	USN	Martin/Maxson			✓	✓	Martin/Maxson	10 5	3 3	1 0	571
	Bullpup B	ASM-N-7b	USN	Martin			✓	✓	Martin	13 0	1 0	1 5	1,785
	Nuclear Bullpup	GAM-83B	USAF	Martin			✓	✓	Martin		3 4	1 1	
	Hound Dog	GAM-77A	USAF	North American			✓	✓	NAA	42 0	12 0	2 7	10,000
	Quail	GAM-72A, B	USAF	McDonnell			✓	✓	McDonnell	13 0	5 5	1 8	1,100
	Shrike		USN	NOTS	✓	✓							
Anti-submarine	Subroc		USN	Goodyear		✓			Goodyear				
Surface-to-air	Bomarc	IM-99A	USAF	Boeing				✓	Boeing	47 0	18 2	3 0	15 000
	Bomarc	IM-99B	USAF	Boeing				✓	Boeing	45 0	18 2	3 0	16 000
	Hawk	XM-3E1	Army	Raytheon			✓	✓	Northrop/LTV	16 5	1 0	1 2	1 295
	Mauler		Army	GD/Pomona	✓	✓			GD/Pomona				
	Nike Ajax	SAM M-1	Army	Western Electric				✓	Douglas	21 0	4 5	1 0	1 000
	Nike Hercules	SAM M-3	Army	Western Electric			✓	✓	Douglas	27 0	7 5	2 0	5 500
	Nike Zeus		Army	Western Electric	✓	✓			Douglas	32 8	3 9	0 7	
	Nike X/Sprint		Army		✓								
	Redeye		Army	GD/Pomona	✓	✓			GD/Pomona	4 0		0 25	20
	Talos	SAM-N-6	USN	Bendix			✓	✓	McDonnell	30 0		2 6	3 000
	Tartar		USN	GD/Pomona			✓	✓	GD/Pomona	15 0		1 0	1 500
	Terrier		USN	GD/Pomona			✓	✓	GD/Pomona	15 0		1 0	3 000
	Typhon LR		USN	Bendix		✓			McDonnell				
Surface-to-surface Strategic and tactical	Atlas D	SM-65	USAF	AFSC/BSD; Space Tech. Labs.[1]		✓	✓	✓	GD/Astronautics	82 0	16 0	10 0	260 000
	Atlas E	SM-65	USAF	AFSC/BSD; Space Tech. Labs.[1]		✓	✓	✓	GD/Astronautics	82 0	16 0	10 0	260 000
	Atlas F	SM-65	USAF	AFSC/BSD; Space Tech. Labs.[1]		✓	✓	✓	GD/Astronautics	82 0	16 0	10 0	260 000
	Jupiter	SM-78	USAF	Chrysler			*	✓	Chrysler	58 0	.....	9 0	110 000
	Mace A	TM-76A	USAF	Martin				✓	Martin	44 0	22 0	4 5	11 800
	Mace B	TM-76B	USAF	Martin				✓	Martin	44 0	22 0	4 0	14 000
	Minuteman	SM-80	USAF	AFSC/BSD; Space Tech. Labs.[1]		✓	✓	✓	Boeing	53 7		6 2	70 000
	Polaris A1		USN	Lockheed			✓	✓	Lockheed MSC	28 0		4 5	28 000
	Polaris A2		USN	Lockheed			✓	✓	Lockheed MSC	31 0		4 5	30 000
	Polaris A3		USN	Lockheed		✓			Lockheed MSC	31 7		4 5	30 000
	Titan I	SM-68	USAF	AFSC/BSD; Space Tech. Labs.[1]			✓	✓	Martin/Denver	98 0		10 0	220 000
	Titan 2	SM-68B	USAF	AFSC/BSD; Space Tech. Labs.[1]		✓	✓		Martin/Denver	103 0		10 0	300 000
Battlefield support—guided missiles	Corporal	GM-M2A1	Army	Firestone-Gilfillan				✓	Firestone	45 0	6 0	2 5	12 000
	Lacrosse		Army	Martin				✓	Martin	10 2	9 0	1 7	2 000
	Lance	Missile B	Army	Ling-Temco-Vought	✓	✓			LTV				
	Pershing	XM-14	Army	Martin/Orlando	✓	✓	✓		Martin	32 5		3 3	10 000
	Redstone	M-8	Army	Chrysler				✓	Chrysler	69 0		6 0	51 000
	Sergeant	SSM-A-21	Army	Sperry/Utah		✓	✓		Sperry/Utah	34 5		2 0	10 000
	Shillelagh	XM-13	Army	Ford/Aeroutronic	✓	✓			Ford/Aeroutronic				
Battlefield support—unguided missiles	Honest John	M-50	Army	Emerson			✓	✓	Emerson	25 3	4 5	2 5	
	Little John	M-51	Army	Army Missile Command			✓	✓	Emerson	13 0	2 0	1 4	776

ABBREVIATIONS
AFSC—Air Force Systems Command
BSD—Ballistic Systems Division
GD—General Dynamics
GE—General Electric
GM—General Motors
lpr—liquid-propellant rocket
LTV—Ling-Temco-Vought
MIT—Mass. Inst. of T
MSC—Lockheed Missi
NAA—North American
NOTS—Naval Ordnance

POWERPLANT			GUIDANCE		PERF	
Associate contractor or manufacturer	No. of engines, designation and type	Total thrust, lb.	Associate contractor or manufacturer	Type	Max. range, naut. mi.	REMARKS
Thiokol	1 x VI-58A2 spr	4 800	Hughes	Semi-active homing radar	d*	About 12 000 produced.
Thiokol	1 x M-58A2 spr	4 800	Hughes	Infra-red	d*	HM-58 modification to production to Sweden as Rb 325.
Thiokol	1 x M-4d spr		Hughes	Semi-active homing radar	d*	More than 2 000 produced.
Thiokol	1 x M-46 spr		Hughes	Infra-red	d*	More than 1 200 produced.
Lockheed	1 x spr		Hughes			
Thiokol	1 x M-60 spr		Hughes	Semi-active homing radar		Nuclear warhead. HM-58 modification with GAR-11 shell and warhead to production to Sweden as Rb 327
Aerojet	1 x spr		None	Unguided		
Naval Prop. Plt.	1 x spr		Philco	Infra-red		Used also by USAF (as GAR-8) NATO Sweden China Japan Australia.
Goodrich	1 x spr		Philco	Infra-red		Under development by NOTS.
Aerojet	1 x J-8 KS 7500 spr		Raytheon	Semi-active homing radar		Sparrow 3a for supersonic launch speeds.
Aerojet	1 x J-4 KS 7500 spr		Raytheon	Semi-active homing radar		Has supersonic launch capab lity
Thiokol/RMD	1 x LR58-RM 2 lpr	12 000	Martin/Maxson	Command	8	Used by USAF as GAM-83A. 250-lb. conv. warhead. Mussia second source.
Thiokol/RMD	1 x LR82-RM lpr		Martin	Command	8	1 000-lb conv. warhead.
Thiokol/RMD	1 x LR88-RM 2 lpr	12 000	Martin	Command, offset capability		Lengthened body for nuclear warhead
Pratt & Whitney	1 x J52 P 3 tj.	7 500	NAA/Autonetics	Inertial	600	Air-launched from Boeing B-52G
General Electric	1 x J85 tj		McDonnell	Inertial	200	Air-launched from Boeing B-52 as decoy
			Texas Instruments			Anti-radial (electromagnetic) missile.
Thiokol	1 x spr.		Kearfott			Fired from submerged sub.
Marquardt	2 x RJ43-MA-3 rj	16 000	Westinghouse	Active homing radar	200	Aerojet lpr booster, nuclear warhead on Into A models.
Marquardt	2 x RJ43-MA-4 rj.	12 500	Kearfott Westinghouse	Active homing radar	400	Thiokol spr booster, nuclear warhead only
Aerojet	1 x XM-22E8 spr		Raytheon	Semi-active homing radar	22	Also in European production for NATO.
Lockheed	1 x spr		Raytheon-Hunreughs	Radar		Mobile weapon. XM-54d amphibious tracked vehicle.
Aerojet	1 x lpr	2 000	Western Electric	Command	25	Hercules spr booster
Thiokol	1 x M-30 spr		Western Electric	Command	75	Hercules spr booster
Thiokol	8 x spr	450 000	Western Electric	Command	100	ICBM high-altitude intercept missile.
					30	ICBM low-altitude intercept missile.
Atlantic Research	1 x spr		OD/Pomona	Infra-red		Fired from infantryman's shoulder with "bazooka" launcher
Bendix	1 x rj		Sperry	Beam-rider-s-a homing	6d	Also for surface-to-surface missions.
Aerojet	1 x spr		Raytheon		10	Dual-thrust dual-grain rocket motor.
Hercules	1 x spr		Sperry	Beam-rider	10	
Bendix	1 x rj		Westinghouse			
NAA/Rocketdyne	2 x LR89-NA-3 lpr	300 500	GE/Burroughs	Radio inertial	d 600	GE Mark 3 re-entry system.
	1 x LR105-NA-3 lpr	67 000				
NAA/Rocketdyne	2 x LR89-NA-5 lpr	380 000	Arma	Inertial	6 000	Avco Mark 4 re-entry system semi-hard launch sites.
	1 x LR105-NA-5 lpr	67 000				
NAA/Rocketdyne	2 x LR89-NA-8 lpr	330 000	Arma	Inertial		Avco Mark 4 re-entry system underground silo launch
	1 x LR105-NA-5 lpr	52 000				
NAA/Rocketdyne	1 x S-3D lpr	150 000	Ford Instr.	Inertial	1 500	Originally Army program deployed in Italy & Turkey until 1963
GM/Allison	1 x J33-A-41 tj.	5 200	Goodyear-Emerson-Radiation Ier	Atrac (Auto. terrain recog. & navigation)	d50	Fired from mobile trailer/launcher.
GM/Allison	1 x J33-A-41 tj	5 200	GM/AC Spark Plug-General Mills	Inertial	1 200	Fired from hardened fixed silo.
Thiokol (1st stage)	1 x XM-55 spr.	290 000	NAA/Autonetics	Inertial	6 300	Avco Mark d re-entry system.
Aerojet (2nd stage)	1 x spr.					
Hercules (2nd stage)	1 x spr.					
Aerojet (1st stage)	1 x spr.		GE Hughes	Inertial	1 200	Guidance system designed by MIT, aboard George Washington class submarines.
Hercules (2nd stage)	1 x spr					
Aerojet (1st stage)	1 x spr		GE Hughes	Inertial	1 500	Aboard Ethan Allen class submarines.
Hercules (2nd stage)	1 x spr.					
Aerojet (1st. stage)	1 x spr		GE Hughes	Inertial	2 500	
Hercules (2nd stage)	1 x spr.					
Aerojet (1st stage)	1 x LR87-AJ-3 lpr	300 000	Bel Tel. Res. Rand	Radio-inertial	6 300	Avco Mark 4 re-entry system solo storage surface launch
Aerojet (2nd stage)	1 x LR91-AJ-3 lpr.	80 000				
Aerojet (1st stage)	1 x LR87 AJ-5 lpr	430 000	GM/AC Spark Plug	Inertial	6 000	GE Mark 6 re-entry system; underground silo launch
Aerojet (2nd stage)	1 x LR91-AJ-5 lpr.	100 000				
Ryan	1 x A1 lpr	20 000	Gilfillan	Command	7d	Also used by Brit sh Army.
Thiokol	1 x M-101E1 spr		Martin	Command	20	Shaped-charge or nuclear warhead
Rocketdyne	1 x spr.		LTV	Simplified inertial		Replacement for Honest John & Lacrosse.
Thiokol (1st stage)	1 x XR-1 spr.		Bendix/Eclipse Pioneer	Inertial	400	Replacement for Redstone.
Thiokol (2nd stage)	1 x XR-2 spr					
NAA/Rocketdyne	1 x A-7 lpr	78 000	Sperry Farragut	Inertial	200	Deployed with U.S. Army units in Europe.
Thiokol	1 x spr	4d 000	Sperry	Inertial	7d	Replacement for Corporal. 1 500-lb. nuclear war head only
	1 x spr		Ford/Aeronutronic	Command		Tank-mounted, ant.-tank missile.
Hercules	1 x M-31A1 spr			Unguided		Also with NATO armies.
	1 x M-26 spr			Unguided		

echnology
ies and Space Co.
Aviation
Test Station

tj—ramjet
RMD—Reaction Motors Division
sor—solid-propellant rocket
lj—turbojet

SUPERSCRIPTS:
e—estimated performance
1—AFSC/BSD is program manager; SYL is systems integration contractor

U.S. Spacecraft

Category	Spacecraft Name	Agency	Prime Hardware Contractor	Maximum Injected Weight (lb.)	Earth Orbit Altitude (mi.)
MANNED SPACECRAFT	Mercury	NASA/MSC	McDonnell	3 000	110
	Gemini	NASA/MSC	McDonnell	7 200	110
	Apollo A	NASA/MSC	NAA	10 000	300
				50 000	200
	Apollo B	NASA/MSC	NAA	50 000	
				84 000	
	Apollo C	NASA/MSC	NAA	84 000	
	Lunar Excursion Module (LEM)	NASA/MSC	Grumman	24 000	
	X-20 (Dyna-Soar)	USAF	Boeing	12 000	300
	Manned Orbital Development Station (MODS)	USAF		20 000 (est.)	
	Manned Orbital Space Station (MOSS)	NASA/MSC		100 000 (est.)	
APPLICATIONS SATELLITES	Tiros	NASA/GSFC	RCA	285	450
	Nimbus	NASA/GSFC	GE/MSD	850	500
	Synchronous Meteorological Satellite (SMS)	NASA/GSFC			22 300*
	Echo 2	NASA/GSFC	In-house	850	650
	Telstar	Commercial	AT&T/BTL	170	3 500–600
	Relay	NASA/GSFC	RCA	173	4 300–700
	Syncom	NASA/GSFC	Hughes	71	22 300*
	Advanced Syncom	NASA/GSFC		560	22 300*
	Medium-Altitude Random-Orbit Comsat	USAF		160	5 000–12 0
	Oscar	ARRL	ARRL	10	400
	Transit	USN/NRL	JHU/APL	260	650–550
	Agena D Gemini Target	NASA/MSC	Lockheed	d 000	110
LUNAR PLANETARY SPACECRAFT	Ranger	NASA/JPL	In house	750–800	
	Surveyor Lander	NASA/JPL	Hughes	2 100	
	Surveyor Orbiter	NASA/JPL	Hughes	1 900	
	Mariner 1, 2	NASA/JPL	In-house	450	
	Mariner R	NASA/JPL	In-house	1 200	
	Mariner C	NASA/JPL	In-house	570	
	Voyager	NASA/JPL		8 000–4 000	
	Solar Probe	NASA		300	
	Pioneer	NASA/Ames	(unselected)	120	
	Outer Planets Spacecraft	NASA			
	Out-of-Ecliptic Plane Spacecraft	NASA			
	Interstellar Probe	NASA			
SCIENTIFIC and ENGINEERING PAYLOADS	Discoverer Series	USAF	Lockheed	2,100	Varies
	Explorer Series	NASA	In-house	Varies	Varies
	Orbiting Astronomical Observatory (OAO)	NASA/GSFC	Grumman	3 000	900
	Orbiting Geophysical Observatories	NASA/GSFC	ETL		
	EGO S-48			1 000	70 000–160
	POGO S-50			1 000	375–160
	Orbiting Solar Observatory (OSO)	NASA/GSFC	Ball Bros.	458	600
	Helios	NASA/GSFC	(unselected)	1 000	600
	ANNA 1-B	NASA/GSFC	JHU/APL	355	730–600
	Injun	USN/NRL	JHU/APL	40	644–344
	Grab (SR Series)	USN/NRL	JHU/APL	d5	644–344
	Trans	USN/NRL	JHU/APL	260	882–838
	Aranis	USAF	GD/A	320	22 300*
	TRS-1	USAF	STL	1 47	
	Bios 2	NASA/Ames	(unselected)	1 000	200–150
	Lofti	USN/NRL	JHU/APL	57	511–117
	Energetic Particles Satellites	NASA/GSFC	In-house		
	S-3a (Explorer 14)			85	d1 000–175
	S-3b (Explorer 14)			190	7 820–134
	Atmospheric Structures Satellite S-8	NASA/GSFC	In house	375	372–155
	Fixed-Frequency Topside Ionosphere Sounder S-48	NASA/GSFC	In house	110	650–540
	Micrometeoroid Detector Satellite S-55 (Explorer 16)	NASA/LRC	In house	222	620 240
	Polar Ionosphere Beacon S-66	NASA/GSFC	In house	70	600
	Interplanetary Monitoring Platform (IMP) S-74	NASA/GSFC	In house	125	180 000–110
	Large Micrometeroid Detector Satellite	NASA/MSFC	Fairchild-Stratos	4,000	800–300
BALLISTIC PROBES	Rigs 1	NASA/Ames	GE/MSD	65	Altitude Ra 1,100 1,10
	Trailblazer 2	NASA/LRC-MIT/LL	In-house	40	200 125
	Fire	NASA/LRC	Republic	200	425 & 2
	Scout Re-entry	NASA/LRC	L-T-V	132	132
	RAM B	NASA/LRC	In-house	17d	57
	Electron Density Profile Probe P-21	NASA/GSFC	In-house	94	4,000 3,0
	Sari	NASA/Lewis	RCA	320	4,000 vari
	Asset	USAF	McDonnell	600	48 1 6

International Spacecraft

	Sputnik Series	USSR		Varies	Varies
	Cosmos Series	USSR		Varies	Varies
	Vostok Series	USSR		10 400	130
	Venus Probe	USSR		1,419	
	Mars I	USSR		1,915	
	Lunik Series	USSR		3,24d, 858 4,037	
	Ariel UK-1 (S-51)	NASA/GSFC-UK	GSFC In-house	150	754–242
	Alouette S-27	NASA CDRF	DRC	320	638–620
	International Satellite S-52	NASA/GSFC-UK	Westinghouse	195	1 000–230

Abbreviations. MSC—Manned Spacecraft Center, OSFC—Goddard Space Flight Center, ARRL—American Radio Relay League, NRL—Naval Research Laboratories, JPL—Jet Propulsion Labo LRC—Langley Research C

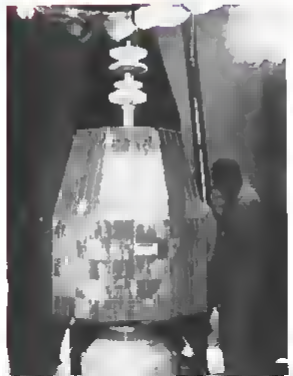
	Date of First Launch	Total Successful Missions	Launch Vehicle	Remarks
	2/20/62	3	Atlas D	Two 3-orbit and one 6-orbit manned mission successful. 18-22 orbit mission planned.
	1964		Titan 2	Rendezvous techniques development. 14-day mission with 2 man. Continued development of spacecraft technology. USAF sharing cost.
	1965-66		Saturn 1	14-day earth orbit test of 3 man command module.
	1966-67		Saturn 1B	Earth-orbit test of rendezvous of command and service modules with lunar excursion module (LEM).
	1967-70		Saturn 5	Circumlunar flight with command and servicer modules.
	1967-70		Saturn 5	Tentative lunar orbit mission to drop LEM loaded with supplies for landing mission to follow.
	1967-70		Saturn 5	Lunar orbit of complete spacecraft with 3 men followed by descent to surface in two-man LEM and exploration.
	1967-70		Saturn 5	Vehicle to land two men on lunar surface from lunar orbit.
	1965		Titan 3C	Hypersonic glide re-entry research in one-man vehicle. Under study.
			Saturn 5	Possible 12-man long-life station under study.
	4/1/60	6	Delta	IR studies and photography of clouds for meteorological satellite development.
	9th prior 63		Thor-Agena B	First operational meteorological satellite.
	1964			Formerly called Aeros.
	2nd qtr 63		Thor-Agena B	Passive communications satellite with 135-ft diameter reflated sphere.
	7/10/62	1	Delta	AT&T funded project to develop wide band commercial communications satellite.
	12/13/62	1	Delta	Feasibility tests of low-altitude one-way active repeater satellite.
	2/14/63		Delta	Lightweight two-way active repeater satellite to synchronous orbit.
			Atlas-Agena B	Larger more sophisticated follow-on to Syncom I. Hughes has study contract.
			Atlas Agena B	Air Force planned system of random-orbit comsats to be launched in groups of up to 8 satellites.
	12/12/62	0	Thor-Agena B	Non-governmental comsat for amateur radio operators, piggy back launches with Discoverer satellites.
	4/13/60	0	Thor-Ablestar	Orbiting navigation beacon development.
	1961-65		Atlas D	Rendezvous target for 2 man Gemini spacecraft.
	6/23/61	2	Atlas-Agena B	Lunar impact, high resolution photography, landing of survivable instrument capsules on the moon.
	1st qtr 65		Centaur	Unmanned lunar landing with payload for examination of lunar crust and environment.
	1965		Centaur	Selenodetic satellite for lunar reconnaissance and photographic mapping, to monitor lunar radiation.
	7/22/62	1	Atlas-Agena B	Sealed-down Mariner A spacecraft which successfully completed Venus fly-by on Dec. 14, 1962 taking magnetometer and radiometer data.
	1965		Centaur	Advanced, improved version of Mariners 1 and 2 which will drop survivable instrument capsules to the surface of Mars and Venus.
	4th qtr. 64		Atlas-Agena D	Mars fly-by vehicle.
	1967		Saturn 1B	Mars/Venus orbiter.
	1966-68		Atlas Agena B	Designed to come within 0.2 A.U. of the sun's surface for close-up observations.
	4th qtr 64		Delta	Solar-orbiting spacecraft (perihelion 0.8 A.U., aphelion 1.2 A.U.) for measurements during the International Quiet Sun Year. Formerly known as PIQSY.
				Fly-by and orbitings of the Jovian planets.
				Investigations of phenomena out of the ecliptic plane.
				Solar system escape spacecraft.
	2/28/59	20	Thor Agena A, B	Development of Agena vehicle and test of designs, techniques and components for military and scientific satellites.
	1/31/58	10	Juno, Scout, Delta	General name for NASA scientific earth satellites. Explorer 1 was first U.S. satellite.
	4th qtr '64		Atlas-Agena B	Orbiting telescope for mapping of heavens in UV spectrum.
				Study of radiation belts, magnetic fields and ionospheric phenomena.
	4th qtr. 63		Atlas-Agena B	Eccentric orbiting geophysical observatory.
	4th qtr. 64		Titan Agena B	Polar orbiting geophysical observatory.
	3/7/62	1	Delta	Study of solar UV and X-radiation.
	1966		Thor-Agena B	Advanced orbiting solar observatory, to study particle radiation as well as electromagnetic radiation.
	10/31/62	1	Thor-Ablestar	Joint Army-Navy-NASA-Air Force geodetic satellite.
	6/29/61	2	Titan-Ablestar	Investigation of earth's radiation belts.
	6/29/61	2	Thor-Ablestar	Study of solar and cosmic radiation.
	11/15/61	1	Thor-Ablestar	Test of gravity gradient stabilization system for Transit satellites.
			Atlas Agena B	Advanced research environment test satellite to study environmental conditions and radiation in synchronous orbit.
		1		Radiation belt mapping.
	4th qtr. 64		Atlas-Agena B	Long term exposure of primates and other biological specimens, recovery by ejected capsule.
	2/21/61	1	Thor Ablestar	Test of propagation of very low frequency radio signals in ionosphere.
				Measurement of artificial radiation created by high altitude nuclear blasts.
	10/2/62	1	Delta	
	10/27/62	1	Delta	
	1st qtr. 63		Delta	Study of composition, density, pressure and temperature of upper atmosphere.
	3rd qtr. 63		Scout	Study of ionosphere from above by measuring electron distribution, electron density and cosmic noise level.
	12/15/62	1	Scout	Study of spatial-temporal distribution of micrometeoroids as hazard to spaceflight.
	2nd qtr. 63		Delta	Study of ionospheric behavior and electron content as well as conditions which disrupt communications.
	4th qtr. 63		Delta	Ascertain Project Apollo radiation hazards, increase solar flare prediction capability, study interterrestrial relationships.
	1965		Saturn 1	Obtain better statistical information of meteoroid distribution with larger area. To be flown in boilerplate command module during a test of Saturn 1 booster.
			Argo D8	Determination of the effects of radiation and weightlessness on biological specimens. Two shots on 11/15/61 and 11/16/61 were unsuccessful due to booster malfunction.
	12/64/61	3	(See Launch Vehicles)	NASA-ARPA-MIT study of re-entry physics.
	3rd qtr. 63		Atlas-Antares 2 A2	Study of radiative heating during re-entry at 37,000 fps. Proposed follow-on Fire 2, would have re-entry velocities as high as 45,000 fps.
			Scout	Study of performance of protective materials.
			Modified Scout	Measurements of radio blackout during re-entry.
			Scout	Study of radio wave propagation and ionospheric electron concentrations.
	1963		Scout	Flight test of ion and arc jet propulsion systems.
	3rd qtr. 63		Thor	Study of aerothermodynamic and aerothermoelastic phenomena during glide re-entry.
	10/4/57	10		Soviet scientific and engineering satellites. Sputnik 1 was first artificial earth satellite. Sputniks 9 and 10 were probably unmanned versions of the Vostok spacecraft.
	3/10/62	12		Soviet scientific satellites.
	4/12/61	1		Manned earth orbiting spacecraft.
	2/12/61	0		Unmanned attempt at Venus fly-by.
	11/1/62	1		Currently under way toward Mars with passage expected in mid-May.
	1/2/59, 9/12/59, 10/4/59	3		Lunik 1, lunar fly-by. Lunik 2, lunar impact. Lunik 3, circumlunar flight yielding photographs of far side of moon.
	4/26/62	1	Delta	International satellite, experiments furnished by British universities.
	9/29/62	1	Thor-Agena B	Canadian swept-frequency topside ionosphere sounder.
	2nd qtr. 64		Scout	Cooperative program with U.K. for study of micrometeoroids, galactic noise and ozone.

laboratory; MSFC—Marshall Space Flight Center. JHU/APL—Johns Hopkins University Applied Physics Laboratory. GO/A—General Dynamics/Astronautics.
entists. CDRB—Canadian Defense Research Board. STL—Space Technology Laboratories. L-T-V—Ling-Temco-Vought.
NAA—North American Aviation. DHC—De Havilland of Canada.

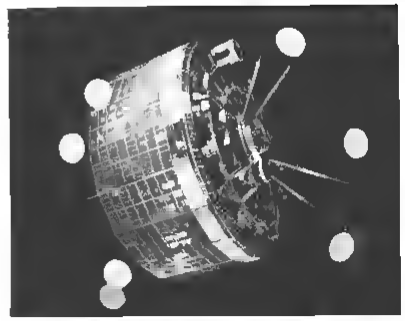
U.S. Launch Vehicles

Vehicle Name	User Agency	Vehicle Contractor	Propulsion: Stage	Propulsion: Engines	Stage Contractor	Stage Designation
Nova	NASA		1	8 x Rocketdyne F-1		N-1
			2	4 x Aerojet M-1		N-2
			3	1 x Rocketdyne J-2	Douglas	N-3
Saturn 5	NASA		1	5 x Rocketdyne F-1	Boeing	S-1C
			2	5 x Rocketdyne J-2	NAA	S-2
			3	1 x Rocketdyne J-2	Douglas	S-4B
Titan 3C	USAF	Martin	1	2 x 120 in. solids	UTC	
			2	2 x Aerojet XLR-87	Martin	Titan 2
			3	1 x Aerojet XLR-91		
			4	1 x Aerojet	Martin	Transtage
Saturn 1B	NASA		1	8 x Rocketdyne H-1	Chrysler	S-1
			2	1 x Rocketdyne J-2	Douglas	S-4B
Saturn 1	NASA		1	8 x Rocketdyne H-1	Chrysler	S-1
			2	6 x P&W A-3	Douglas	S-4
Little Joe 2	NASA	GD/Convair	1	7 x Aerojet	GD/Convair	Algol 1D
Titan 2	NASA/USAF	Martin	1	2 x Aerojet XLR-87	Martin	
			2	1 x Aerojet XLR-91		
Atlas D	NASA/USAF	GD/A	1	2 x Rocketdyne LR89-3	GD/A	
			1	1 x Rocketdyne JR105-3		
Thor	NASA/USAF	Douglas	1	1 x Rocketdyne MB3-2	Douglas	
Scout (XRM 90)	NASA	L-T-V	1	1 x Aerojet XM-68	L-T-V	Algol
			1a	1 x Aerojet		Algol 2
			2	1 x Thiokol XM 33-20		Castor
			3	1 x ABL X254 A1		Antares
			3a	1 x ABL X250		Antares-2
			4	1 x ABL X248		Altair
			4a	1 x ABL X258		Altair-2
			5	1 x NOTS 100A (spherical)		Orion
Blue Scout I (XRM 99)	USAF	L-T-V	1	1 x Aerojet XM-68	L-T-V	Algol
			2	1 x Thiokol XM 75		Castor
			3	1 x ABL X251 A0		Antares
Blue Scout 2 (XRM 90)	USAF	L-T-V	1	1 x Aerojet XM-68	L-T-V	Algol
			2	1 x Thiokol XM-56		Castor
			3	1 x ABL X254-A2		Antares
			4	1 x ABL X248-A6		Altair
Blue Scout Jr. (XRM 91)	USAF	L-T-V	1	1 x Thiokol XM-33	L-T-V	Castor
			2	1 x ABL X254-A1		Antares
			3	1 x Aerojet AJ10-41		Altair
			4	1 x NOTS 100A		Orion
Trailblazer 2	NASA	In-house	1	1 x Aerojet XM-33		Castor
				2 x Thiokol XM-10		Recruit
			2	1 x Thiokol TX-77		Seat
			3	1 x ABL X 248		Altair
			4	1 x spherical solid		
Centaur	NASA	GD/A	2	2 x P&W A-4	GD/A	Centaur
Agena B	NASA/USAF	Lockheed	2	1 x Bell 8096	Lockheed	Agena B
Ablestar	USAF/USN	Douglas	2	1 x Aerojet AJ 10-104	Aerojet	Ablestar
Delta	NASA	Douglas	2	1 x Aerojet AJ 10 118	Douglas	Altair
			3	1 x ABL X248		

Contractors.
Rocketdyne—Rocketdyne Div. of North American Aviation, Inc.
Aerojet—Aerojet General Corp.
P&W—Pratt & Whitney Aircraft Div. of United Aircraft Corp.
UTC—United Technology Center.
ABL—Hercules Powder Co., Allegheny Ballistics Laboratory.
NOTS—Naval Ordnance Test Station.
Bell—Bell Aerosystems Co., Div. of Bell Aerospace Corp.
L-T-V—Ling-Temco-Vought.
GD/A—General Dynamics/Astronautics.



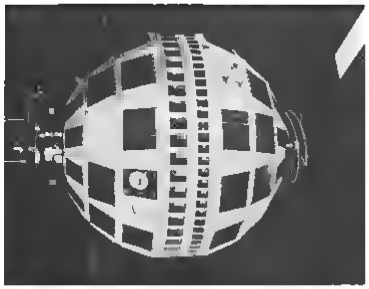
Relay



Tiros

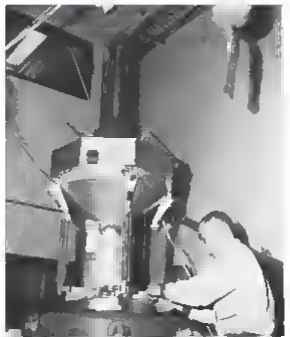
Propellant (oxidizer/fuel)	Nominal Thrust (1 000 lb.)	Max. Diameter (ft.) (excluding fins)	Height (ft.) (excluding payload)	Gross Launch Weight (1 000 lb.)	Payload (1 000 lb.) 300-mi. Orbit	Payload (1 000 lb.) Earth Escape
LO_2/RP	12 000	50	100+	6 500	375	150
LO_2/LH_2	4 800					
LO_2/LF_2	200					
LO_2/RP	7 500	33	275	6 034	225	90
LO_2/LH	1 000					
LO_2/LHr	200					
Solid	>2 000	30	120		25	
N_2O_4/NH_2-NH_2-UDMH	410					
N_2O_4/NH_2-NH_2-UDMH	100					
N_2O_4/UDMH	16					
LO_2/RP	1 500	21 6	141	1 250	28 5	
LO_2/LH_2	200					
LO_2/RP	1 500	21 6	125	1 120	20	
LO_2/LH_2	90					
Solid	720	12 8	90	246	80 000 lb	to 400 000 ft.
N_2O_4/NH_2-NH_2-UDMH	430	10	90	300	8	
N_2O_4/NH_2-NH_2-UDMH	100				(150 mi.)	
LO_2/RP 1	300 | 337	10	72	260	3	
LO_2/RP 1	97 |				(100 mi)	
LO_2/NF	170	8	81	110		
Solid	120	3 3	55	36	0 14	
Solid	150					
Solid	55					
Solid	13					
Solid	10					
Solid	3					
Solid	5					
Solid	900					
Solid	120	8 3	72	53		
Solid	55					
Solid	13					
Solid	120	8 3	72	55 9		
Solid	55					
Solid	13					
Solid	3					
Solid	55	2 8	30	18 3		
Solid	13					
Solid	8					
Solid	100					
Solid	142	2 75	51 5	13 5		
Solid	38 5					
Solid	3 1					
Solid	5 5					
LO_2/LH_2	30	10	25	31	8 5	2 3
IRFNA/UDMH	15	6	30	15	5 (Atlas) 35 (Thor)	0 75 (Atlas)
IRFNA/UDMH	7 87				25 (Thor,	
IWFNA/UDMH	7 7	8	2"		5 (Thor)	06 (Thor)
Solid	2 8					

Propellants:
LO_2—Liquid Oxygen
N_2O_4—Nitrogen Tetroxide
IRFNA—Inhibited Red Fuming Nitric Acid
IWFNA—Inhibited White Fuming Nitric Acid
RP—Rocket Propellant (Kerosene)
LH—Liquid Hydrogen
UDMH—Unsymmetrical Dimethyl Hydrazine
NH_2-NH_2—Hydrazine



Telstar

Saturn SA-5



S 3B

Space Vehicle Log

Satellites Transmitting Data	Name	Source	Launch Date	Inclination (deg)	Period (min)	Apogee (mi)	Perigee	Transmitting Frequency (mc)	Weight in Orbit (lb)
1958 Beta 2	Vanguard 1	USN	Mar. 17, 1958	34.25	133 9	2,460 9	393 4	108 024	3 25
1961 Omicron 1	Transit 4A	USN	June 29, 1961	66 81	103 8	618 9	548	54, 150; 324; 400	175
1961 Omicron 2	Injun SR3	USN	June 29, 1961	66 82	103 8	619 5	548	136 5	40
1962 Beta 1	Tiros 4	NASA	Feb. 8 1962	48 29	100 3	521 4	443 7	136 23, 136 92	285
1962 Zeta 1	OSO-1	NASA	Mar. 7, 1962	32 83	95 9	371	337 8	136 744	440
1962 Omicron 1	Ariel	NASA/UK	Apr. 26, 1962	53 85	100 7			136 408	
1962 Alpha Alpha 1	Tiros 5	NASA	June 19, 1962	58 08	100 5	596 8	371 6	136 235; 136 922	281
1962 Alpha Epsilon 1	Telstar 1	NASA	July 10, 1962	44 80	157 6	3,506 1	586	136 05	170
1962 Alpha Psi 1	Tiros 6	NASA	Sept. 18, 1962	58 29	98.7	438 9	430 9	(Same as Tiros 5)	285
1962 Beta Alpha 1	Alouette	Canada	Sept. 29, 1962	80 48	105 5	645 6	617 7	136 979	320
1962 Beta Gamma 1	Explorer 14	NASA	Oct. 2, 1962	36 27	2,184 6	62,366	343	136 44	89
1962 Beta Lambda 1	Explorer 15	NASA	Oct. 27, 1962	18 03	314 9	10,942 2	193 2	136 101	311
1962 Beta Mu 1	Anna 1B	USN	Oct. 31, 1962	50 13	107 8	735 6	668 9	54- 162; 216; 324	385
1962 Beta Upsilon 1	Relay 1	NASA	Dec. 13 1962	47 49	185 0	4,620 9	819 8	136 140; 136 620	172
1962 Beta Chi 1	Explorer 16	NASA	Dec. 16	51 99	104.3	722 5	474 2	136 858	159
1962 Beta Psi 1	Transit 5A	USN	Dec. 19	90 63	99.2	463.6	435 6	150, 400	135
1962 Beta Omega 1	Cosmos 12	USSR	Dec. 22	65 0	90 45	251 1	130 8	19 995	

Other 1962 Launches

Payload/Vehicle	Source	Launch	Decay	Remarks
Ranger 3	NASA	Jan. 26		In solar orbit
Friendship 7	NASA	Feb 20	Feb 20	Manned
Thor Agena B	USAF	Feb 21	Mar 4	
Discoverer 38	USAF	Feb. 27	Mar. 21	
Atlas Agena B	USAF	Mar. 7		In orbit
Cosmos 1	USSR	Mar. 16	May 25	
Cosmos 2	USSR	Apr. 6		In orbit
Thor Agena B	USAF	Apr 18	May 29	
Ranger 4	NASA	Apr. 23	Apr. 26	Impacted moon
Cosmos 3	USSR	Apr. 24	Oct. 17	
Cosmos 4	USSR	Apr. 26	Apr. 29	
Atlas Agena B	USAF	Apr. 26	Apr. 29	
Thor Agena B	USAF	Apr 29	May 26	
Thor Agena B	USAF	May 15		In orbit
Aurora 7	NASA	May 24	May 24	Manned
Cosmos 5	USSR	May 28		In orbit
Thor Agena B	USAF	May 30	June 11	
Thor Agena B/ Oscar	USAF	June 2	June 28	
Atlas Agena B	USAF	June 2	June 21	
Atlas Agena B	USAF	June 17	June 18	
Thor Agena B	USAF	June 18		In orbit
Thor Agena B	USAF	June 23	July 7	
Thor Agena D	USAF	June 28	Sept 14	
Cosmos 6	USSR	June 30	Aug 8	
Telstar 1	NASA	July 10		In orbit
Atlas Agena B	USAF	July 18	July 25	
Thor Agena B	USAF	July 21	Aug 14	
Thor Agena B	USAF	July 28	Aug 24	
Cosmos 7	USSR	July 28	Aug 1	
Thor Agena D	USAF	Aug. 2	Aug 26	
Thor Agena B	USAF	Aug 5	Aug 6	
Vostok 3	USSR	Aug 11	Aug 15	Manned
Vostok 4	USSR	Aug 12	Aug 15	Manned
Cosmos 8	USSR	Aug. 18		In orbit
Blue Scout	USAF	Aug 23		In orbit
Venus Probe	USSR	Aug 25		Launch from orbit failed
Mariner 2	NASA	Aug 27		Flew past Venus Dec 14
Thor Agena D	USAF	Aug 29	Sept 10	
Planetary Probe	USSR	Sept 1		Launch from orbit failed
Planetary Probe	USSR	mid-Sept		Launch from orbit failed
Thor Agena B	USAF	Sept 17	Nov 19	
Cosmos 9	USSR	Sept. 27		Presumed in orbit
Thor Agena D	USAF	Sept 29	Oct. 14	
Sigma 7	NASA	Oct. 3	Oct. 3	Manned
Thor Agena B	USAF	Oct. 9	Nov. 16	

Payload/Vehicle	Source	Launch	Decay	Remarks
Cosmos 10	USSR	Oct 16		Presumed in orbit
Ranger 5	NASA	Oct 18		In solar orbit
Cosmos 11	USSR	Oct 20		Presumed in orbit
Thor Agena D	USAF	Oct 26		In orbit
Mars Probe	USSR	late-Oct.		Launch from orbit failed
Mars Probe	USSR	Nov. 1		On trans-Mars trajectory
Thor Agena B	USAF	Nov. 5	Dec. 3	
Atlas Agena B	USAF	Nov. 11	Nov. 12	
Thor Agena B	USAF	Nov. 24	Dec. 13	
Thor Agena	USAF	Dec 4	Dec. 8	
Thor Agena/Injun	USAF	Dec 13		In orbit— 4 unidentified piggybacks
Thor Agena	USAF	Dec. 14		Presumed in orbit
Tetrahedral Research Satellite	USAF			Presumed in orbit

Summary

	Launched	In Orbit	Transmitting
1957—USSR	2	0	0
1958—US	5	2	1
USSR	1	0	0
1959—US	11	4	0
USSR	3	1	0
1960—US	17	10	0
USSN	3	0	0
1961—US	35	12	2
USSR	5	1	0
1962—US	54	32	14
USSR	19	7	
1963—US			
USSR			

Notes: NASA stopped reporting Air Force and Soviet launches in December, 1962. In its space activity reports to the UN, the Soviet Union does not include information on orbit decay. Previous log was published Nov. 5, 1962, p. 71.

Sources: Aviation Week & Space Technology, National Aeronautics and Space Administration, North American Air Defense Command, United Nations reports, and the Smithsonian Astrophysical Observatory.

U.S. Sounding Rockets

Manufacturer	Name	Agency	Over-all length, ft.	Diameter, ft.	Launch weight, lb.	Powerplant: Stage, Manufacturer, Engine designation, Rated thrust	Remarks
Space-General Corp., El Monte, Calif.	Aerobee 150	NASA/USAF	25 75	1 25	1 460	1st—Aerojet AJ10-140 1pr. @ 2 600 lb. t.	Tower launched. Uses Aerojet 2 0KS-15 000 lb. t. booster 3 6m.
	Aerobee 150	Navy USAF	30 0	1 25	1 900	1st—Aerojet AJ11-21 1pr @ 4 150 lb. t.	Corrosive acid propellant makes immediate launch necessary.
	Aerobee 150A	NASA	23 75	1 25	1 900	1st—Aerojet AJ60-13 1pr @ 4 100 lb. t.	Uses Aerojet 2 0KS-18,000 lb. t. booster 4 0m.
	Aerobee 300	USAF	32 5	1 25	2 200	1st—Aerojet AJ60-13 1pr @ 4 100 lb. t. 2nd—Douglas Sparrow 1 8KS spr @ 7,800 lb. t	Similar to Aerobee 150 or 150A
	Aerobee 300A	NASA	34 3	1 25	2 200	1st—Aerojet AJ60-13 1pr @ 4 100 lb. t 2nd—Douglas Sparrow 1 8KS spr @ 7,800 lb. t	
	Aerobee 900		28 6	1 32	2 260	1st—HPC ABL M5 @ 48 700 lb. t. 2nd—ARC 30KS8000 @ 8840 lb. t.	
	Astrobee 940 Astrobee 1500	USAF	34 2 34 2	2 7 1 8	10 350 11 165	1st—Aerojet Jt @ 127 600 lb. t. 1st—Aerojet Jt @ 123 800 lb. t. 2nd—ARC 30KS8000 @ 8840 lb. t.	
[illegible]	Argo [illegible]	USAF	37 0	2 0	7 300	1st—HPC/ABL M 6 @ 86,000 lb. t. 2nd HPC/ABL M 5 @ 48 700 lb. t. 3rd—HPC/ABL M5 @ 18 700 lb. t. 4th Thiokol TX-22-26 @ 3,150 lb. t. 5th Thiokol T-55 @ 1 850 lb. t.	Janus 50 lb payload to 800 n mi
	Argo D-1	NASA/USAF	48 0	2 0	7 300	1st—HPC/ABL M6 @ 86,000 lb. t 2nd—HPC/ABL M5 @ 48,700 lb. t. 3rd HPC/ABL M 5 @ 48,700 lb. t 4th HPC/ABL X 248 @ 3,150 lb. t.	Javelin 1000 lb. payload to 800 n. mi
	Argo D-8	NASA	62 0	2 6	14 300	1st Thiokol XM-20 TX-17-2 @ 150 000 lb. t 2nd LPC Lance @ 47 000 lb. t 3rd - LPC Lance @ 47,000 lb. t 4th—HPC/ABL X 248 @ 3 150 lb. t	Altair Journeyman 150 lb payload to 1200 n. mi.
	Argo A-1	NASA	21 0	2 6	10 000	1st Thiokol TX-33/TX 77 2 @ 150 000 lb. t.	Percheron 1st stage in Shotput.
	Argo B-1	NASA/USAF	24 0	1 41	1 540	1st HPC ABL M5 @ 48,700 lb. t 2nd Thiokol Cajun @ 9,600 lb. t	40 lb payload to 150 n. mi
	Argo E-22	USAF	43 5	2 0	9 000	1st—HPC/ABL M 6 @ 86 000 lb. t. 2nd HPC/ABL M 5 @ 18,700 lb. t 3rd HPC/ABL M 5 @ 48 700 lb. t	150 lb. payload to 110 n. mi.
	Argo C-23	USAF	41 3	7 0	14 300	1st—Thiokol TX-33-41 Castor @ 150 000 lb. t. 2nd—Thiokol TX-281 Pedro @ 40 000 lb. t. 3rd—Thiokol TX-239 spherical	200 lb. payload to 1 900 n. mi (guided or to guided vehicle.
[illegible]	Metro	Army NASA	4 45	0 3	29	1st—ARC 10KS140 @ 140 lb. t.	2 lb. payload to 10 mi.
	Booster-Metro	Army	4 0	0 3	40	1st—ARC 10KS140 @ 140 lb. t. 2nd 2.75FFAR @ 700 lb. t	3 lb. payload to 45 mi
	Arrow	NASA USAF Army/Navy	7 7	0 4	77	1st ARC 28KS335 @ 335 lb. t.	12 lb. payload to 42 mi.
	Arrow Robin	USAF	6 5	0 4	73	1st—ARC 28KS335 @ 335 lb. t.	8 lb. payload to 45 mi
	Sidewinder-Arrow	Navy USAF Army	14 0	0 4	169	1st NPP Sidewinder	12 lb. payload to 80 mi.
	Archer	NASA Navy USAF	19 5	0 6	336	2nd—ARC 28KS335 @ 335 lb. t 1st—ARC 36KS1375 @ 1375 lb. t.	50 lb. payload to 110 mi. Uses 0 0KS11,000 booster at launch
	Sparrow-Archer	Navy	15 5	0 7	430	1st—Douglas Sparrow @ 7800 lb. t.	50 lb. payload to 135 mi.
	Nike-Archer	Navy/USAF	23 6	1 4	1 655	2nd—ARC 38KS1375 @ 1375 lb. t. 1st—HPC/ABL M 5 @ 48 700 lb. t.	50 lb. payload to 220 mi
	Nike-Cajun	NASA/USAF/Army/Navy	23 0	1 4	1 500	2nd—ARC 38KS1375 @ 1375 lb. t. 1st—HPC/ABL M 5 @ 48 700 lb. t. 2nd Thiokol Cajun @ 9,600 lb. t.	90 lb. payload to 90 mi.
	Nike-Apache	NASA USAF/Army/Navy	23 0	1 4	1 500	1st—HPC/ABL M 5 @ 48 7 00 lb. t. 2nd—Thiokol Apache @ 6 000 lb. t.	50 lb. payload to 150 mi.
	Iris	NASA USAF	23 B	1 0	1 125	1st—AGC 52KS4375 @ 4375 lb. t.	150 lb. payload to 180 mi Tower launched was 0.8KS 18,000 booster
	Castor-X254	USAF	31 0	2 6	11 500	1st—Thiokol XM-33 @ 52,000 lb. t. 2nd ABL X254-A2 @ 14 000 lb. t.	300 lb. payload to 600 mi
B F Goodrich Aerospace & Defense Products, Seattle, Calif.	Loki 1	USAF Army Navy	5 5	0 25	17 11	1st—0 8KS3200 @ 3200 lb. t.	For sleds and probes
	Loki 2	USAF Army Navy	5 9	0 25	24 1	1st—1 0KS7500 @ 1980 lb. t.	For sleds and probes.
	Hasp 2	Navy	5 6	0 25	32 6	1st 1 0KS-2000 @ 1980 lb. t.	9.5 lb. shaft payload to 38 mi. altitude
	Hasp 2	Navy	5 6	0 25	34 1	1st—1 0KS-2000 @ 1980 lb. t.	10 lb. instrumented payload to 38.4 mi. altitude
Douglas Aircraft Co., Santa Monica, Calif.	Recruit	USAF	8 9	0 8	181	1st DM-16A/ATO @ 7800 lb. t.	Air-launched 40 lb payload
Hercules Powder Co., Wilmington, Del.	Deacon	NASA	5 2	0 5	153	1st HPC ABLX 220 @ 5,800 lb. t.	First successful launch 1947 used in wide variety of experiments.
The Marquardt Corp., Van Nuys, Calif.	Asp 1	Navy	12 0	0 5	218 5	1st—Marquardt spr @ 5,850 lb. t.	Carried 50 lb. payload to 80 mi altitude
	Asp 1A	Navy	12 B	0 5	240	1st—Marquardt spr @ 2750 lb. t.	Capable of lifting 50 lb. payload 80 mi high.
	Aspan 150	USAF	20 4	1 4	1 503	1st—HPC ABL M5 @ 48 700 lb. t. 2nd—Marquardt spr @ 5 850 lb. t.	Nike 1st stage Asp 1 2nd stage.
	Aspan 300	Navy	20 4	1 4	1 503	1st—HPC/ABL @ 48,700 lb. t. 2nd—Marquardt spr @ 2 750 lb. t.	Capable of lifting 50 lb. payload 200 mi. high
	Bon	USAF	39 0	1 0	5 505	1st—HPC ABL M6 @ 86,000 lb. t. 2nd—HPC/ABL M5 @ 48,700 lb. t. 3rd—HPC/ABL M 5 @ 48 700 lb. t.	Designed to lift 500 lb. payload 70 mi. high
	Nike Nike	USAF	22 2	1 3	5 505	1st—HPC/ABL M5 @ 48,700 lb. t. 2nd—HPC ABL M5 @ 48,700 lb. t.	Also called Python.
	Roksonde 300	USAF/Army	5 3	0 4	29 5	1st—Marquardt spr @ 2 000 lb. t.	Designed to lift payload 40 mi. high.
North American Aviation Inc. Rocketdyne Div., Canoga Park, Calif.	Aerolas 1-50	Navy	4 23	0 35	41	1st—NAA @ 318 lb. t.	
	Aerolas 1-250	Navy	7 27	0 36	60	1st NAA @ 500 lb. t.	

Abbreviations: LPC—Lockheed Propulsion Co. HPC ABL—Hercules Powder Co. Allegheny Ballistics Laboratory NAA North American Aviation, Rocketdyne Div. ARC Atlantic Research Corp.

U.S. Gas Turbine Engines

Manufacturer and Address	Military designation	Type	No. compressor stages	No. turbine stages	No. combustors	Max. power at S. L.	Specific fuel consumption at max. power	Compression ratio at max. rpm	Max. envelope diameter in.	Max. envelope length in.	Dry weight less jetpipe lb.	Remarks
Avco Corp. Lycoming Div *Stratford, Conn*	T53-L-11A -13	ACFS	5	1	1	860 shp.	0.77	5.0	23	47-61	481	Bell UH-1A, Kaman HH-43B
	T53-L-3	AFF	5	1	1	901 shp.	0.68	9.0	23	55-10	524	Grumman OV-1
	T53-L-5	ACFS	5	1	1	901 shp.	0.65	6.0	23	47-60	487	Bell UH-1B
	T53-L-7	AFF	5	1	1	1,100 shp.	0.67	9.0	24	47-60	555	Advanced Grumman OV-1A
	T53-L-9, 9A -9B	ACFS	5	1	1	1,100 shp.	0.68	9.0	23	4-01	488	Bell 204, Bell UH-1D
	T53-L-11	ACFS	5	1	1	1,100 shp.	0.68	9.0	23	47-61	505	Bell UH-1E
	T55-L-5	ACFS	7	2	1	2,200 shp.	0.62	6.0	21.25	41-21	570	Vertol CH-47A
	T55-L-7	ACFS	7	2	1	2,650 shp.	0.61	8.0	24.25	11-9	580	Vertol CH-47A (Advanced)
	LTC4G-3	AFF	7	2	1	2,115 shp.	0.62	6.0	21.25	62.22	755	North American YAT-28E
The Boeing Company *Seattle, Wash.*	T50-BO-8A	CFS	1	2	2	900 shp.	0.98	4.6	24	10	350	Navy DASH anti-submarine testbed for canned drone helicopter program
	T50-BO-10	ACFS	1	2	2	350 shp.	0.85	4.0	22.5	35.5	238	(As above)
	T60-BO-4	CFS	1	2	2	550 shp.	0.72	6.1	25.5	55	265	Turbofuel
	T60 (520-10)	CFS	1	2	2	800 shp.	0.68	6.2	25.5	55	240	Turbofuel
	T60 (520-11)	CFS	1	2	2	700 shp.	0.68	6.2	25.5	57.2	290	Turbofuel
	550	ACFS	1	2	2	450 ehp.	0.77	5.3	22.5	57.0	187	Turbofuel
	502 12B	CFG	2	2	2	205 shp.		4.3	28	46	440	Compressed-air output
Continental Aviation & Eng'g Corp. *Detroit, Mich.*	J69-T-25	CFJ	1	1	1	1,025 lb. t.	1.14		24.0	50	364	Cessna T-37B
	J69-T-29	ACFJ	1	1	1	1,700 lb. t.	1.10			48.3	355	Ryan Q-2C
	J69-T-29	ACFJ	2	2	1	2,650 lb. t.	0.80	6.1	22.3	44	385	Target missile engine
	T65-T1	ACFS	2	3	1	250 shp.	0.71	5.3	18.3	38.7	130	
	217 6B	ACFS	1.5	3	1	600 shp.	0.63		19.4	42.5	220	Turbofuel
	217 7B	ACFP	1.5	3	1	450 eshp.	0.63		19.4	42.5	245	Turboprop
	141	CFG	1	1		141 shp.					157	For pressure-jet helicopter
	156-23	ACFJ	3	2	1	2,100 lb. t.	0.58	6.1	22.3	47	410	
Curtiss-Wright Corp. Wright Aeronautical Div *Wood Ridge, N. J.*	J65 W-16A	AFJ	13	2	1	7,200 lb. t.			37.5	113	0.787	North American AF-1E
	J65 W-18	AFJ	13	2	1	10,500 lb. t.			37.5	181	3.485	Grumman F-11A
Garrett Corp. AiResearch Mfg. Co. *Phoenix, Ariz.*	GTP30	CFS	1	1	1	50 shp.	1.46	3.0	17.8	20.8	87.5	Portable generators
	GTCP30	CFSG	1	1	1	50 shp./20 shp.	1.00	3.0	17.8	20.8	80.5	On board power Jet Star, Gulfstream
	GTP70	CFS	2	1	1	150 shp.	1.1	3.0	30.0	31.0	224	Sergeant missile support
	GTC85	CFG	2	1	1	182 shp.	1.07	4.0	25.7	35.5	247	Airport ramp support
	GTCP85	CFSG	2	1	1	345 shp., 215 shp.	1.07	4.0	25.8	42.4	294	On board auxiliary power for B-727, BAC-111, B-141, Caravelle, KC-135
	GTCP100	CFSG	2	2	6	100 shp./165 shp.	1.00	5.5	25.0	36.5	359	B-52 ramp support
	T76E31	CFFFS	2	3	1	300 shp.	0.62	3.5	25.4	40.0	290	Drilocrete engine
	GTP85II	CFS	2	3	1	400 shp.	0.65	0.5	38	50	858	Permanent generator installations
General Electric Co. Flight Propulsion Div *Evendale, Ohio*	J47-GE-25	AFJ	12	1	8	7,200 lb. t.	1.06	5.4	38.3	145	2.584	Boeing B-47E, water/alcohol injection
	J47-GE-27	AFJ	12	1	8	8,270 lb. t.	1.03	6.4	39.3	148	2.907	No afterburner
	J47-GE-33	AFJ	12	1	8	7,650 lb. t.	1.15	5.5	39.3	228	3.190	Afterburner
	J73-GE-3	AFJ	12	2	8	9,920 lb. t.	0.92	7.0	36.6	147	3.650	No afterburner
	J79-GE-2	AFJ	17	3	10	16,100 lb. t.	1.37	12.0	38.3	208	3.020	McDonnell F-4E, North American A-5A
	J79-GE-5B	AFJ	17	3	10	15,800 lb. t.	2.01	12.0	38.3	207	3.325	Lockheed F104A, B
	J79-GE-5B	AFJ	17	3	10	15,800 lb. t.	2.08	12.2	38.3	207	3.038	Convair B-58
	J79-GE-7	AFJ	17	3	10	15,800 lb. t.	1.97	12.2	38.3	205	3.375	CF-104, F-104C, D
	J79-GE-8	AFJ	17	3	10	17,000 lb. t.	1.93	12.0	38.3	208	3.630	McDonnell F-4B, North American A-5A
	J79-GE-11A	AFJ	17	3	10	15,800 lb. t.	1.97	12.2	38.3	208	3.486	Lockheed F104G
	J79-GE-15	AFJ	17	3	10	17,000 lb. t.	1.94	12.5	38.3	208	3.668	McDonnell F-4C
	J93 GE-3	AFJ				30,000 lb. t.						For NAA RS-70
	X353-5B	AFLF	8.1	2.1	1	2,450 lb. lift	0.38	1.1	70.0	14.0	1.145	Lift-fan for XV-5A
	CJ805-3A	AFJ	17	3	10	11,200 lb. t.	0.81	13.0	32	189	2.500	Convair 880, length includes reverser
	CJ805-3B	AFJ	17	3	10	11,650 lb. t.	0.81	13.0	32	189	2.815	Convair 880 M, length includes reverser
	CJ805-23	AFF	17	3	10	10,050 lb. t.	0.56	13.0	53	140	3.700	Aft-fan engine, Convair 990A
	CJ805-23C	AFF	17	3	10	16,100 lb. t.	0.57	13.0	53	160	3.800	Aft-fan with reverser, Carravelle Super A
Lynn, Mass	T58-GE-8B	AFS	10	3	1	1,250 shp.	0.61	8.3	15	80	295	SH-3A, UH-2A, CH-46A, CH-3B, HH-52A, VH-3A, CH-113, X-22A
	T64-GE-2	AFS	14	4	1	2,810 shp.	0.56	12.5	30	91	864	de Havilland Caribou testbed
	T64-GE-4	AFS	14	4	1	2,850 shp.	0.49	12.6	30	113	1.130	XC-142A, CH-53A
	T64-GE-8 (was 1)	AFS	14	4	1	2,850 shp.	0.50	12.6	30	83	713	de Haviland CV7A
	T64-GE-8	AFS	14	4	1	2,850 shp.	0.49	12.6	40	113	1.139	Northrop T-38A, Bell X-14A Afterburner
	J85-GE-5A	AFJ	*	2	1	2,850 lb. t.	0.90	6.6	22	100	503	Northrop F-5A, Afterburner
	J85-GE-13	AFJ	*	2	1	4,080 lb. t.	2.22	6.8	22	110	570	Vertol 107, S-61, S-62, Commercial T58
	CT58-110	AFS	10	3	1	1,250 shp.	0.61	8.3	15	80	304	Aero Commander 112, Lear Jet-C-1201, Piaggio, Douglas PD-808, Commercial J85
	CJ610-1	AFJ	8	2	1	2,850 lb. t.	0.99	6.8	18	41	391	Aft-fan J85 frame
	CF700-2D	AFF	8	3	1	4,200 lb. t.	0.80	6.6	34	88	840	
General Motors Corp. Allison Div *Indianapolis, Ind.*	T56-A-1	AFF	14	4	6	3,760 shp.	0.54	9.2	38	148	1.045	Lockheed C-130A
	T56-A-7	AFF	14	4	6	4,050 shp.	0.53	9.7	37	148	1.033	Lockheed C-130B
	T56-A-8	AFF	14	4	8	4,050 shp.	0.53	9.5	41	148	1.072	Grumman E-2A
	T56-A-9	AFF	14	4	8	3,750 shp.	0.54	9.2	37	145	1.073	Lockheed C-130A, GA-1
	T56-A-10W	AFF	14	4	6	4,595 shp.	0.53	9.5	41	145	1.353	P-3A, water/alcohol injection
	T63-A-5	ACFS	5.1	4	1	240 shp.	0.71		22.5	40.5	130	For Army LOH
	501-D13	AFF	14	4	6	3,750 shp.	0.54	9.2	41	146	1.045	Lockheed Electra
Solar *San Diego, Calif.*	T62-S-2	CFS	1	1	1	80 shp.	1.10	3.4	15.8	34.7	61	Single shaft, constant-speed, APU
	T350 (Mfr. no.)	CFS	1	1	1	370 shp.	1.0	4.1	26	38	105	Single shaft, air bleed, combination APU

Continued on page 198

Note: Type of engine is designated by capital letters. First, or first two, designate compressor: A = axial, C = centrifugal. Next letter, F, stands for flow. Final letter or letters define output: J = jet, P = pre-poller, F = fan, S = shaft, G = gas, and LF = lift fan. For example: AFLF = Axial-flow lift fan.

ABBREVIATIONS
ehp. — Air horsepower
eshp. — Equivalent shaft horsepower
lb. t. — Pounds of thrust
shp. — Shaft horsepower

U.S. Gas Turbine Engines continued

Manufacturer and Address	Military designation	Type	No. compressor stages	No. turbine stages	No. combustors	Max. power @ S.L.	Specific fuel consumption at max. power	Compression ratio at max. rpm	Max. envelope diameter, in.	Max. envelope length, in.	Dry weight less tailpipe, lb.	Remarks
United Aircraft Corp. Pratt & Whitney Aircraft Division *E. Hartford, Conn.*	TF33-P-3	AFF	15	1	8	17,000 lb. t.	0.52	13.0	53		3,900	JT3D-2, B-52H
	TF33-P-5	AFF	15	1	8	18,000 lb. t.	0.54	13.0	53		4,170	JT3D-3A, Boeing C-135B
	TF33-P-7	AFF	16	1	8	21,000 lb. t.	0.61	16.0	53		4,400	JT3D-8A, Lockheed C-141
	TF33-P-9	AFF	15	1	8	18,000 lb. t.	0.54	13.0	53		4,170	JT3D-3A, Boeing KC-135B
	J52-P-3	AFJ										JT8A for Hound Dog missile
	J52-P-6A	AFJ	12	2	9	8,500 lb. t.	0.82	12.0	30	106	2,056	JT8B-1, Douglas A-4E, Grumman A-6A
	J52-P-8	AFJ	12	2	9	9,300 lb. t.	0.88	12.0	30	106	2,118	JT8B-3
	J57-P-20	AFJ	16	3	8	18,000 lb. t.	2.35	13.0	38.9	253	1,703	JT3C-26, F-8D
	J57-P-43WB	AFJ	16	3	8	11,200 lb. t.	0.66	13.0	38.9	167	3,870	JT3C, B-52F & G
	J58	AFJ				30,000 lb. t.						
	J60-P-3	AFJ	9	2	8	3,000 lb. t.	0.96	6.5	21.9	76	436	JT12A-6, North American T-39, Lockheed C-140
	J60-P-1	AFJ	9	2	8	3,300 lb. t.	1.00	6.5	21.9	78	465	JT12A-7
	J75-P-19W	AFJ	15	3	8	26,500 lb. t.	2.20	12.0	43.0	259	5,960	Water inj.+afterburner, Republic F-105D
	JT3C-6	AFJ	16	3	8	13,500 lb. t.	0.78	13.0	38.9		4,231	Boeing 707-120, Douglas DC-8-10
	JT3C-7	AFJ	16	3	8	12,000 lb. t.	0.78	13.0	38.9		3,495	Boeing 720
	JT3C-12	AFJ	16	3	8	13,000 lb. t.	0.82	13.0	38.9		3,550	Boeing 720
	JT3D-1	AFF	16	4	8	17,000 lb. t.	0.52	13.0	53		4,050	Boeing 707-120B, 720B, Douglas DC-8-50
	JT3D-3	AFF	16	4	8	18,000 lb. t.	0.54	13.0	53		4,170	Boeing 707-320B, C; Douglas DC-8-50, DC-8F
	JT3D-5A	AFF	16	4	8	21,000 lb. t.	0.61	16.0	53		4,195	Lockheed L-300
	JT4A-9	AFJ	15	3	8	16,800 lb. t.	0.84	12.0	43	111	5,096	Douglas DC-8-20, -30; Boeing 707-320
	JT4A-11	AFJ	15	3	8	17,500 lb. t.	0.84	12.0	43		5,100	Douglas DC-8-20, -30; Boeing 707-320
	JT8D-1	AFF	13	4	9	14,000 lb. t.	0.63	16.0	43		2,884	Boeing 727, Caravelle Super B
	JT8D-5	AFF	13	4	9	12,000 lb. t.	0.57	11.0	43		2,984	Transport engine
	JFTD12A-1	AFF	9	1	8	4,050 shp.		6.8			870	Sikorsky S-64 Skycrane
	JFTD12A-3	AFF	9	1	8	4,050 shp.	0.66	6.8			870	Free turbine shaft drive
	JT12A-6	AFJ	9	2	8	3,000 lb. t.	0.96	6.5	21.9	76	436	Lockheed Jet Star, NAA Sabreliner
	JT12A-8	AFJ	9	2	8	3,300 lb. t.	1.00	6.5			465	Dassault Mystere 20
	JT12A-21	AFJ	9	2	8	3,925 lb. t.	2.12	6.5	21.9		451	Afterburner

U.S. VTOL Aircraft

Manufacturer and Address	General Data			Dimensions			Weights			Powerplants					Remarks
	Designation	Type	No. of seats	Span	Length	Height	Wing area, sq. ft.	Empty weight, lb.	Gross weight, lb.	Number, make and model	Rotor-propeller diameter	No. of propellers	Service ceiling, ft.	Maximum speed, mph	
Bell Aerosystems Co., *Buffalo, N. Y.*	X-22A (tri-service VTOL transport)	Tilting propellers	8	39' 2"	36' 4"	19' 7"	108	10,500	15,000	4 GE T58-8	7	4		325	
Curtiss-Wright Corp. *Wood Ridge, N. J.*	X-19	Tilting propellers	6	34' 1"	45' 3"	16' 9"		10,000	13,300	2 Lyc. T55-L-5	13' 0"	4	25,300	460	
Hawker Siddeley Aircraft Ltd. *Great Britain*	Hawker P. 1127 (XV-6A)	British VTOL strike-reconnaissance fighter for U. S. Army use	1	24' 3"	41' 2"	10' 7"				1 Bristol Siddeley Pegasus lift/thrust		0			
Lockheed-Georgia Co., *Marietta, Ga.*	XV-4A (VZ-10) (Hummingbird)		2	25' 8"	32' 8"	11' 8"	104	4,995	7,200	2 P&W JT12A-3		0		520	First flight July 1962
Piasecki Aircraft Corp. *Philadelphia, Pa.*	VZ-8PA (AirGeep I)	Ducted fan	1	9' 4"	26' 1"	6' 7"		2,000	2,350	1 AiResearch TSE 331-6	7' 6"	2			Tactical ground support
	VZ-8PB (AirGeep 2)	Ducted fan		9' 3"	24' 4"	5' 8"		2,600	3,670	2 Turbomeca Artouste IIC		2			VZ-8P with ground powered wheels
Ryan Aeronautical Co. *San Diego, Calif.*	VZ-3RY	Vectored slipstream	1	23' 4"	27' 7"	10' 7"	125	2,233	2,718	1 Lyc. T53	9' 2"	2			
	XV-5A (VZ-11)	Lift fan	2	29' 7"	44' 1"	14' 6"	260	4,951	9,200	GE X353-5	5' 0"		40,000		
Vanguard Air & Marine Corp., *Bala-Cynwyd, Pa.*	Model 2C	Fan-in-wing with ducted pusher prop.	2	22' 0"	29' 1"	6' 3"			3,100	1 Lyc. T53	6' 5"	2			Testbed. Wing-buried rotor-props.
Vertol Division The Boeing Co., *Morton, Pa.*	VZ-2A (Model 76)	Tilt wing	2	24' 9"	26' 1"	10' 6"	110	2,800	3,200	1 Lyc. T53	9' 5"	2			

U. S. Reciprocating Engines

Manufacturer and Address	Designation	No. of cylinders	Cylinder arrangement	Propeller drive	Power Ratings: Max. takeoff power at S.L. hp	At rpm	Normal rated power hp.	At rpm	At altitude, ft.	Fuel grade	Diameter or dimensions in. (without cowling)	Blower ratio	Dry weight lb.
Avco Corp., Lycoming Div. Williamsport, Pa.	O-235-C1B	4	Ho	Direct	115	2 800	108	2 600	S.L.	80	22.5x32		216
	O-290-D2	4	Ho	Direct	140	2 800	135	2 600	S.L.	80/87	22.8x31.24		[illegible]
	O-320-A2C	4	Ho	Direct	150	2 700	150	2 700	S.L.	80/87	23.12x32.24		271
	O-320-B2C	4	Ho	Direct	160	2 700	160	2 700	S.L.	91/96	23.12x32.24		277
	IO-320-A1A	4	Ho	Direct	150	2 700	150	2 700	S.L.	80/87	19.40x32.24		270
	O-360-A1D	4	Ho	Direct	180	2 700	180	2 700	S.L.	91/96	24.72x33.37		284
	HO-360-B1A	4	Ho	Direct	180	2 900	180	2 900	S.L.	91/96	19.88x33.47		288
	VO-360-A1B	4	Vo	Direct	180	2 900	180	2 900	S.L.	91/96	21.42x33.37		298
	IO-360-B1A	4	Ho	Direct	180	2 700	180	2 700	S.L.	91/96	22.47x33.37		281
	TVO-360-B1B	4	Ho	Direct	225	4 100	225	4 100	S.L.	100/130	17.47x33.37		274
	VO-435-A1E	6	Vo	Direct	260	4 100	250	4 200	S.L.	80/87	14.73x33.53		301
	VO-435-A1F	6	Vo	Direct	260	4 400	250	3 200	S.L.	80/87	24.13x33.58		406
	GO-435-C2B2-6	6	Ho	Gear	260	3 400	215	4 100	S.L.	80/87	28.02x33.42		435
	TVO-435-A1A	6	Vo	Direct	250	3 200	220	3 200	20 000	100/130	35.81x33.58		468
	GO-480-B1D	6	Ho	Gear	270	3 400	260	3 000	S.L.	80/87	28.02x34.12		432
	GO-480-G1F6	6	Ho	Gear	295	3 400	290	4 000	S.L.	100/130	27.10x34.12		447
	GSO-480-B1B6	6	Ho	Gear	340	3 400	320	3 200	8 000	100/130	33.28x33.12		500
	IGSO-480-A1B6	6	Ho	Gear	340	3 400	320	3 200	11 500	100/130	23.29x33.12		[illegible]
	O-540-B1A5	6	Ho	Direct	235	2 575	235	2 575	S.L.	80/87	21.58x33.37		395
	O-540-E1B5	6	Ho	Direct	260	2 800	235	2 800	S.L.	91/96	21.58x33.37		398
	O-540-A1D5	6	Ho	Direct	250	2 575	250	2 575	S.L.	91/96	21.58x38.12		[illegible]
	VO-540-B1B	6	Vo	Direct	305	3 200	305	3 200	S.L.	80/87	21.5x34.14		420
	VO-540-A1A	6	Vo	Direct	305	3 200	405	3 200	S.L.	80/87	24.58x34.20		458
	IO-540-A1A5	6	Ho	Direct	290	2 575	290	2 575	S.L.	100/130	19.92x34.25		441
	IO-540-B1A5	6	Ho	Direct	290	2 575	290	2 575	S.L.	100/130	19.60x33.25		[illegible]
	IO-540-C1A5	6	Ho	Direct	250	2 575	250	2 575	S.L.	91/96	22.21x33.17		403
	IGO-540-B1A	6	Ho	Gear	350	3 400	325	3 300	S.L.	100/130	21.64x34.25		501
	IGSO-540-B1A	6	Ho	Gear	380	3 400	380	3 200	11 500	100/130	20.29x31.25		532
	TVO-540-A1A	6	Vo	Direct	305	3 200	305	3 200	17 000	100/140	16.00x34.20		498
	IO-720-A1A	8	Ho	Direct	400	2 650	380	2 650	S.L.	100/130	46.7x34.2		609
Continental Motors Corp. Muskegon, Mich.	A-65-8F	4	Ho	Direct	65	2 300	65	2 300	S.L.	80/87	31.0x31.56		176
	C-85-12F	4	Ho	Direct	85	2 575	85	2 575	S.L.	80/87	31.29x31.50		184
	C-90-12F	4	Ho	Direct	90	2 475	90	2 475	S.L.	80/87	31.25x31.56		188
	E-185-6	6	Ho	Direct	205	2 600	185	2 300	S.L.	80/87	47.62x33.38		352
	O-200-A	4	Ho	Direct	100	2 750	100	2 750	S.L.	80/87	30.51x31.56		190
	E-225-8	6	Ho	Direct	225	2 650	185	2 300	S.L.	80/87	47.62x33.38		355
	O-300-A, B, C, D	6	Ho	Direct	145	2 700	145	2 700	S.L.	80/87	38.35x31.50		268
	GO-300-A, B, C, D	6	Ho	G .750:1	175	3 200	175	3 200	S.L.	80/87	35.82x31.50		311
	O-470-4	6	Ho	Direct	225	2 600			S.L.	91/96			415
	O-470-15	6	Ho	Direct	213	2 600			S.L.	80/87			405
	O-470-J	6	Ho	Direct	225	2 550	225	2 550	S.L.	80/87	36.03x33.32		378
	O-470-K, L	6	Ho	Direct	230	2 600	230	2 600	S.L.	80/87	36.03x33.56		401
	O-470-G, M, R[1]	6	Ho	Direct	240	2 600	240	2 600	S.L.	91/96	37.56x33.56		410
	IO-470-J, K	6	Ho	Direct	225	2 600	225	2 600	S.L.	80/87	37.93x33.50		401
	IO-470-C, G, P, R	6	Ho	Direct	250	2 600	250	2 600	S.L.	91/96	37.93x33.56		432
	IO-470-D, E, F, H, L, M, N	6	Ho	Direct	260	2 625	260	2 625	S.L.	100/130	13.53x33.56		426
	TSIO-470-B	6	Ho	Direct	260	2 600	260	2 600	18 000	100/130	12.82x33.36		427[2]
	TSO-526-A[2]	6	Ho	Direct	270	3 200	270	3 200	7 000	91/96	50.11x38.61	16.04	583
Franklin Engine Co., Inc. Syracuse, N. Y.	4A4-100-B3	4	Ho	Direct	100	2 550				80			200
	6A4-150-B3	6	Ho	Direct	180	2 400				80			276
	6A4-165-B3	6	Ho	Direct	165	2 800				80			273
	6AGI-185-B12	6	Ho	G .632:1	165	3 100				80			232
	6A4-200-C6	4	Ho	Direct	200	3 100				91			[illegible]
	6A4-200-C12[3] (6V4-200-C32)-335-8-5	6	Vo	Direct	200	3 100				91			297
	6V6-245-B16F[3] D-425-1	6	Vo	Direct	245	4 275				91			372
	6V-335-A, B	6	Vo	Direct	210	3 100				91			295
	6AS-335	6	Ho	Direct									
Pratt & Whitney Aircraft Div. United Aircraft Corp. East Hartford, Conn.	R2000-D5	14	Rad	G .500	1 450	2 700	1 200	2 550	6 100	100/130	48.10	7.15	1 585
	R2000-2SD13-G	14	Rad	G .500	1 450	2 700	1 200	2 550	5 800	100/130	48.10	7.15+8.52	1 605
	R2800-CB3	18	Rad	G .450:1	2 400	2 800	1 800	2 600	8 500	108/135	52.80	7.29	2 357
	R2800-CB4	18	Rad	G .450:1	2 500	2 800	1 800	2 600	8 500	108/135	52.80	7.29	2 387
	R2800-CB16	18	Rad	G .450:1	2 400	2 800	1 800	2 600	8 500	100/130	52.80	7.29+8.56	2 380
	R2800-CB17	18	Rad	G .450:1	2 500	2 800	1 800	2 600	8 500	108/135	52.80	7.29+8.56	2 400
	R2800-CB25-54	18	Rad	Direct	2 100	2 100	1 800	2 600	7 000	115/145	52.80	7.29	2 330
	R2800-CB15-695	18	Rad	G .450:1	2 500	2 800	1 800	2 600	7 000	115/145	52.80	7.29+8.56	2 465
Wright Aeronautical Div. Curtiss Wright Corp. Wood-Ridge, N. J.	987C9HE1,2 / R1820-82-82A	9	Rad	G .5625:1	1 525	2 800	1 275	2 500	1 900	115/145	55.74	7.21	1 460
	975TC18EA1,2 / R3350-32W-32WA	18	Rad	G .4375:1	3 700	2 900	2 800	2 600	4 100	115/145	55.6	6.46	3 500
	983C9HE57 / R1820-84C-84D	9	Rad	Direct	1 525	2 800	1 275	2 500	4 400	115/145	55.74	7.21	1 419
	983C9HE12	9	Rad	Direct	1 525	2 800	1 275	2 500	1 500	115/145	55.74	7.21	1 410
	990C7BA1	7	Rad	Direct	800	2 600	700	2 400	7 100	91/98	50.40	7.21	1 090
	982C9HE1,2	9	Rad	G .5625:1	1 525	2 800	1 275	2 500	1 500	115/145	54.95	7.21	1 460
	988C9HE1,2	9	Rad	Direct	1 525	2 800	1 275	2 500	3 500	115/145	55.75	7.21	1 422
	977C9HD3	9	Rad	Direct	1 425	2 700	1 275	2 500	4 300	100/130	54.95	7.21	1 405
	988TC18EA6	18	Rad	G .4375:1	3 400	2 900	2 800	2 600	4 700	115/145	56.59	6.46	3 712

G Geared
Ho Horizontally opposed
Rad Radial
S.L. Sea level
Vo Vertically opposed
[1] For helicopter installation
[2] Extended propeller shaft
[3] Engine has a 40-lb. turbocharger that is mounted separate

U. S. Airlines' Transport Fleet

Manufacturer	Model designation	Popular name or sub-type designation	General: Number in flight crew	General: Number of passengers	General: Cargo capacity lb	Dimensions: Wingspan, ft.	Dimensions: Max. length, ft.	Dimensions: Max. height ft.	Weights: Empty weight lb	Weights: Normal gross weight, lb.	Weights: Max. landing weight lb.	Powerplant: Number, make & model	Performance: Max. speed, mph.	Performance: Best airline speed, mph.	Performance: Landing speed mph.	Performance: FAA takeoff field length, ft.	Performance: FAA landing field length, ft.	Performance: Max. with-air range, mi.
BAC	111	One-Eleven	2-3	75		88 5	92 1	23 8	43 340	73 500	64 500	2 R.-R Spey R 9 168-2	553	500				
Boeing	707-120	Jet Stratoliner	3-4	100-156	10 200	130 8	145 1	42 0	113 540	257 000	185 000	4 P&WA JT3C-6	615	540	160	10 000	6 200	3 650
	707-120 B	Jet Stratoliner	3-4	100-156	10 200	130 8	145 1	42 0	118 000	257 000	185 000	4 P&WA JT3D 3	625	540	157	7 000	6 100	4 715
	707-220	Jet Stratoliner	3-4	100-156	10 200	130 8	145 1	42 0	117 400	247 000	185 000	4 P&WA JT4A-3	615	535	157	8 300	5 200	3 000
	707-320	Intercont nental	3 4	110-174	28 200	145 8	152 0	42 5	132 924	312 000	207 000	4 P&WA JT4A 11	610	525	164	10 700	7 300	5 874
	707-320B	Intercont nental	4	110 174		145 8	152 0	42 5	129 154	321 000	207 000	4 P&WA JT3D 3B	625	520	147	10 150	6 400	6 216
	707-320C	Intercont nental	3-4	110-189	30 000	145 8	152 0	42 5	140 000		207 000	4 P&WA JT3D-3B	600+	520	147	8 500	5 100	6 274
	707-420	Intercontinental	3-4	108 180	28 200	145 8	152 0	42 5	131 244	316 000	207 000	4 R.R.Co. 12	615	525	164	10 200	7 500	5 300
	720	Jet Stratoliner	3	92 139	16 680	130 5	138 8	41 6	101 355	212 000	175 000	4 P&WA JT3D-3	595	532	149	7 500	5 150	3 915
	720B	Jet Stratoliner	3	92 149	17 040	130 5	138 8	41 5	107 250	234 000	175 000	4 P&WA JT3D-3	625	535	151	8 100	5 450	4 284
	727		3	70-111	24 000	108 0	134 0	34 0	78 110	142 000	121 000	3 P&WA JT8D 1	620	530		6 350	5 000	1 185
Canadair	CL-44		4		55 000	142 3	136 8	38 8	87 516	316 000	165 000	4 R.R Tyne 12		380		7 000*	5 000	
CVA	FBY-5A	Cruisaire	3			101 0	63 A	18 8	17 584	34 000		2 P&WA R1830-90	196	140				2 520
CW	C-46		2-3			108 1	76 3	21 8	28 483	48 000		2 P&WA R2800	311	227				
Douglas	DC-3		2-3	21-28		95 0	64 5	16 6	18 000	25 000		2 Wr R1820	216	197				
	DC-4		3-5	44		117 5	93 5	27 5	38 200	73 000	53 500	1 P&WA R2000		240				
	DC-6		3-5	48-58		117 5	100 7	28 4	54 485	97 200		4 P&WA R2800-CA18	356	313	81			4 610
	DC-6A		3-5	None	5 000*	117 5	105 5	28 4	56 747	100 000		4 P&WA R2800-CB17	360	311	83			4 140
	DC-6B		3-5	54-86		117 5	105 0	28 4	57 148	107 000	83 000	4 P&WA R2800-CB17	360	311	83			4 540
	DC-7		3-5	56-95	14 200	117 5	108 9	28 0	60 305	122 000	97 000	4 Wr R3350 18DA1	400+	3584	105*			5 000
	DC-7B		3-5	40-83		117 5	108 9	28 0	62 998	122 000	102 000	4 Wr R3350-18DA4	400+	3584	100*			4 540*
	DC-7C	Seven Seas	5	62-99	15 140	127 5	112 3	31 7	72 763	143 000	108 000	4 Wr R3350-18EA1	400	348	97	8 360	5 100	4 670
	DC-7CF		3	0	33 000	117 5	108 3	28 6				4 Wr R3350						5 000
	DC-8	Series 10	3	115-179	20 850	142 5	150 5	42 3	120 000	272 000	193 000	4 P&WA JT3C-6	580	514	148	8 625	6 410	5 490
	DC-8	Series 20	3	116-176	20 850	142 5	150 5	42 3	121 757	276 000	199 500	1 P&WA JT4A-6 11	600	544	151	7 500	6 500	5 780
	DC-8	Series 30	3-5	116-176	20 850	142 5	150 5	42 3	126 672	316 000	207 000	4 P&WA JT4A-9 11	610	544	153	9 000	6 800	6 140
	DC-8	Series 40	3-5	116-176	20 850	142 5	150 5	42 3	121 856	315 000	20 000	1 R.R.R Co. 12	600	544	155	9 650	6 800	7 380
	DC-8	Series 50	3-5	116-176	20 850	142 5	150 5	42 3	124 525	316 000	202 000	1 P&WA JT3D-3	600	514	153	8 460	5 950	5 000
	DC-8F	Jet Trader	3-5		91 113	142 5	150 5	42 3	126 163	315 000	246 000	4 P&WA JT3D-3	600	511	160	9 100	7 000	8 700
Fairchild	F-27A	Friendship	2	40-44		95 3	77 2	27 5	25 344	38 500	37 500	2 R.R.R Dv 7/2	300	280	84	4 350	3 440	1 870
GD Conv	240		2	40		91 8	74 8	26 5	27 600	41 700	38 900	2 P&WA R2800-CA18	347	270	88			1 500
	340		2	44		105 3	78 8	28 2	29 500*	47 000	46 000	2 P&WA R2800-CB16		293		4 675	4 500	2 000
	440	Metropolitan	3	44-52		104 0	72 5	28 2	31 905	49 100	47 650	2 P&WA R2800-CB17	310	280	90	4 000	4 410	2 275
	580		2-4	44-110	8 630*	105 0	79 1	28 3	31 800	58 000	55 000	2 GE CJ805-3	315	0 848	138	6 000*	6 250*	2 200
	880-22M		3-4	88-110	8 100*	120 0	129 3	37 3	88 300	193 500	155 000	4 GE CJ805-23B	615	0 848	148	5 200*	5 400*	3 900
	990-30A-6		3-4	56-121	9 280*	120 0	139 8	36 8	114 750	245 000	209 000	4 GE CJ805-23B	623	0 859	128	8 100*	5 200*	4 200
Lockheed	749	Constellation	3-4	44-69	4340	123 0	93 2	23 0	57 500*	107 000	87 500	4 Wr R3350	350+	328	85			3 500
	1649	Super Constellation	3-4	94-82	4 610	123 0	113 6	24 8		137 500	117 000	4 Wr R3350	380+	327	95	5 200*	3 300*	5 350
	1049	Starliner	5+	58-92	33 600	150 0	116 2	23 4	85 267	156 000	123 000	4 Wr 988TC18EA2	377	342	101	5 700	3 500	7 200
	188	Electra	3-4	66-85		99 0	104 5	31 8	57 500	116 000	98 650	1 AD 501D-13	450	405	120	5 250	4 000	2 405
Martin	202		2	36-40	2800	93 3	77 3	28 4	28 530	38 000		2 P&WA R2800 A18	311	266	75	1 565	1 720	635
	404		3	40	3100	93 3	71 6	28 1	29 425	43 000	43 000	2 P&WA R2800 B16	312	280	79	2 000*	1 700*	2 000
Sud	Caravelle 6R		2-3	64-70		112 5	105 0	29 5	63 206	110 231		2 R-R Avon 531R	534					
Vickers	744/8	Viscount	2	38		93 3	81 8	26 0	37 310	64 500		4 R R Dart 505 510		318		5 280	4 000	2 050
	812	Viscount	2	52		93 7	85 9	26 8	41 000	64 500	58 500	4 R R Dart 525		357		5 920	4 450	1 760
WCA	AW 650	Argosy	2-3		28 000	113 0	88 8	26 3	39 850	82 000		4 R-R Dart 526		291		3 050	2 280	3 000

ABBREVIATIONS
BAC—British Aircraft Corp.
CVA—Consolidated-Vultee Aircraft
CW—Curtiss-Wright
GD—General Dynamics
GE—General Electric
P&WA—Pratt & Whitney Aircraft
R-R—Rolls-Royce
WGA—Westworth Gloster Aircraft
Wr—Wright Aeronautical Div.

SUPERSCRIPTS
1 Operating weight empty
2 At 200,000 lb. gross takeoff weight
3 Cubic feet of cargo space
4 Estimated

5 At 10 lb. sq. ft.
6 Mach number
7 For 1,000 nmi. range
8 Full payload and 10 000 lb. reserve
9 Full payload and 16 000 lb. reserve

MODIFIED AMERICAN AIRLINES CONVAIR 990 awaits delivery from General Dynamics/Convair plant.

U.S. Rotary-Wing Aircraft

Manufacturer and Address	Model number	DOD designation	Popular name	Number in crew	Number of passengers	Rotor diameter, ft.	Maximum length, blades parallel, ft.	Maximum height, ft.	Empty weight, lb.	Normal gross weight, lb.	Number...make & model	Max speed mph.	Hovering ceiling in ground effect, ft.	Still-air range, mi.	REMARKS
Bell Helicopter Co. Fort Worth, Texas	47G-2A			1	2	37 0	43 2	9 3	1 838	2 850	1 Lyc VO-435 re.	105	4 500	225	
	47G-2A-1			1	2	37 0	43 2	9 3	1 850	2 850	1 Lyc VO-435 re	105	4 500	360	
	47H-1B			1	2	37 0	43 2	9 3	1 600	2 850	1 Lyc TVO-435 re	105	18 000	260	
	47J-2 Ranger			1	2	37 0	43 2	9 3	1 791	2 950	1 Lyc TVO-435 re.	105	16 400	273	
	47G-3		Ranger	1	3	37 0	43 2	9 3	1 740	2 850	1 Lyc VO-540 re	108	9 900	260	
	204B			1	9	48 0	53 0	13 1	4 500	8 500	1 Lyc LTC1K-2 ts.	138	8 200	230	
		TH-13N		1	1	37 0	43 2	9 3	1 916	2 565	1 Lyc O-335-5 re	103	8 500	184	
	204	UH-1B	Iroquois	1	7-9	44 0	53 0	12 7	4 300	9 500	1 Lyc T53-L-9 ts.	138	10 000	235	
		UH-1D	Iroquois	1	12	44 0	53 9	13 4	4 813	8 600	1 Lyc T53-L-9 ts.	138	16 700	292	
											1 Alf T63 A-5 ts.				
	205	OH-1A		1	3										One of three competing in Army LOH program
		GH-13S	Sioux	1	2	37 0	43 2	9 2	1 600	2 850	1 Lyc TVO-435-A1A re.	105	18 000	200	
		UH-1E		1	7-9	41 0	53 0	12 7	4 300	8 500	1 Lyc T53-L-9 ts.	138	16 700	235	
Bensly Helicopter Corp. Burbank, Calif.	B-9A			1	1	23 1		7 0	1 010	1 600	1 Lyc VO-360-M1A re	100	5 050	200	
R. J. Enstrom Corp. Menominee, Mich.	F-28			1	2	32 5	20 0	9 1	1 200	1 950	1 Lyc O-360-A1A re.	115	8 910	235	
Gyrodyne Co. of America Inc. Port Jefferson, N.Y.	GCA-4I			1	0	17 0	17 0	8 0	325	715	1 Sol T62 ts.	72	10 500	18	
	GCA-59			1	0	20 0	20 0	9 0	530	910	1 GCA/Porsche XD-95-6 re	77	7 500	112	
Hiller Aircraft Co. Palo Alto, Calif.	F4	OH-23D	Raven	1	2	35 1	40 5	9 8	1 410	2 700	1 Lyc VO-435 re	95	5 200	200	
	12F	OH-23F	Raven	1	3	35 1	42 5	9 8	1 775	2 750	1 Lyc VO-540 re	90	10 000	225	
		OH-23G	Raven	1	2	35 1	36 8	9 8	1 758	2 800	1 Lyc VO-540 re	90	10 000	226	
		Test99		1	6		39 0	10 0		3 500	1 CP & WA PT6 ts				
											1 Alf T63 A-5 ts.				
	1100	OH-5A		1	3										One of three competing in Army LOH program
	L4			1	3	35 0	46 0	9 5	1 340	3 100	1 Lyc TIVO-540 A1A re	105			
Hughes Tool Co. Aircraft Division Culver City, Calif.	269A			1	1	25 0	28 0	8 0	910	1 550	1 Lyc O-360 C2D re.	88	6 300	210	
	369	OH-6A		1	3						1 Alf T63 A-5 ts.				One of three competing in Army LOH program
Kaman Aircraft Corp. Bloomfield, Conn.		HH-43A	Huskie	1-2	3-4	47 0	47 0	12 4	4 300	7 850	1 P&W R1340 re	119	14 200	220	
		HH-43B	Huskie	1-2	11	47 0	47 0	12 6	4 600	9 150	1 Lyc T53-L-13 ts.	120	25 000	250	
		UH-2A	Sea Sprite	4	10-14	44 0	52 2	12 4	6 815	10 001	1 HF T51-GE-8B ts	147	11 500	360	
	1125		Huskie 3	2	12				5 295	10 170	2 Bo YT60-WO-94 ts.				
Kellett Aircraft Corp. Willow Grove, Pa.	KD-1A			1	1	30 0	30 0	10 8	1 300	2 200	1 Jacobs L-4MA re.	110	14 000	100	Autogyro test vehicle
Lockheed-California Co. Burbank, Calif.	1-1-475			2		32 0				2 000	1 150-hp. re				Rigid rotor test vehicle
	1-L-595	XH-51A		2							1 1 P&WA PT6 ts.				Rigid-rotor research heli copter
Omega Aircraft Corp. New Hyde Park, N.Y.	BS-12D-1			1	1	30 0	38 4	13 0	3 A15	1 750	2 Lyc O-a-10-F135 re	95*	4 800	195	
	BS-12 D3B			1	A	39 0	48 1	13 0	3 100	5 200	2 Fr 6S-335 re	95	4 250	195	First flight scheduled early March 1963
Piasecki Aircraft Corp. Philadelphia, Pa.	16H		Pathfinder	1-2	4-5						1 1 P&WA PT6 A ts.				Compound helicopter with swing tail rotor
Sikorsky Aircraft Division Stratford, Conn.	S-58	CH-34	Choctaw	1-2	18	56 0	65 5	14 3	7 030	14 000	1 Wr R1820-84 re.	123	4 000	182	
	S-61A	CH-3B		2	28	62 0	72 7	18 8	6 911	13 000	2 GE T58-GE-8B ts.	150	7 400	340	
	S-61R	SH-3A	Sea King	3-4		62 0	72 5	15 7	11 191	17 000	2 GE T58-GE-80 ts.	140	10 000	535	
	S-61L			3	28	62 0	72 5	16 9	11 733	19 000	2 GE CT58-110-1 ts.	148	6 700	270	Also S-61N with 25-28 passengers.
	S-61R	CH-3I		3	25/30	62 0	72 8	18 1	11 248	16 535	2 GE T58-GE-80 ts.	158	8 200	484	
	S-62	HH-52		1-2	10	53 0	58 3	14 2	4 787	7 900	1 GE CT58-140-1 ts.	109	15 700	265	
	S-64			2-5	3-2	72 0	87 8	18 5	17 240	38 000	2 P&WA JFTD12A-1 ts.	117	9 700	161	
	S-65	CH-53A		3	30	72 0				33 150	2 GE T64-GE-6 ts.				
Vertol Division, Boeing Co. Philadelphia, Pa.	42	CH-21A	Shawnee	1-2	14	44 0	86 3	16 0	9 300	11 500	1 Wr R1820-103 re.	140	14 000	450	
	43	CH-21C	Shawnee	1-2	20	44 0	86 3	16 0	9 600	15 000	1 Wr R1820-103 re	140	9 100	590	Also CH-21B
	44			2	10	44 0	86 3	15 3	8 980	11 500	1 Wr R1820-103 re	127	5 400	290	
	107			2	22	18 3	81 7	16 8	9 100	15 500	2 Lyc T53 ts	141			
	107-II	CH-46A	Sea Knight	2	25	50 0	83 3	16 9	10 585	18 450	2 GE CT58-110 ts.	162	10 600	215	
	114	CH-47A	Chinook	3	33	50 1	98 1	18 6	16 118	31 000	2 Lyc T55-L-5 ts.	178	13 100	253	

ABBREVIATIONS

All—Allison Division
Bo—Boeing Co.
CP&WA—Canadian Pratt & Whitney
Fr—Franklin Engine Co.
GCA—Gyrodyne Corp. of America
GE—General Electric Co.
LOH—Light observation helicopter
Lyc—Lycoming Div. Avco Corp.
P&WA—Pratt & Whitney Aircraft Div.
re.—Reciprocating engine
Sol—Solar
ts.—Turboshaft engine

SUPERSCRIPTS

1—At 3 000-ft. altitude
2—At 4,000-ft. altitude

U.S. Business and Personal Aircraft

Manufacturer and Address	Designation	Basic Data: No. of seats	Overall span	Overall length	Max. height, 3-pt.	Gross wing area, sq. ft.	Weight empty, lb.	Normal gross wt., lb.	Powerplants: Number, make, model and max. rating, ea.	Performance: Normal fuel capacity, gal.	Max. speed, mph.	Landing speed, mph	FAA field length (takeoff), ft.	FAA field length (landing), ft.	Max. range, mi.	Price, FAF, $
Aero Commander, Inc. Bethany, Okla	Jet Commander 1121	8	46 3"	48'	15 8"	303	6,116	14,000	2 GE CJ610	979	560	95	1,558	2,210	1,625	475,000
	Grand Commander	11	49 0	41 8"	14 5	285	6,012	8,000	2 Lyc. IGSO-540	225	290	77	1,580	1,930	1,310	139,000
	Aero Commander 680F-P (Pressurized)	7	49 0'	35 1	14 6'	255	4,800	8,000	2 Lyc. IGSO-540B1A	220	290	77	1,360	1,330	1,530	168,500
	Aero Commander 690F	7	49 0	36 1"	14 5	255	4,400	8,000	2 Lyc. IGSO-540B1A	223-285	290	77	1,380	1,330	1,310	121,000
	Aero Commander 500F	7	49 0	36 1	14 5	255	4,700	7,000	2 Lyc. IGO-540B1A	223-285	248	73 §	1,350	1,375	1,750	105,000
	Aero Commander 500B	7	49 0'	35 1"	14 5	255	4,328	6,750	2 Lyc. IO-540B1A5	158	233	68	1,300	1,155	1,305	87,000
	Aero Commander 500A	7	49 0	35 1	14 5	255	4,390	6,350	2 Con. IO-470	135	228	66	1,200	1,150	1,000	72,000
Beda Aircraft, Inc. Springfield, Ohio	BD-1	2	35 0"	15 2	7 8	92	500	1,100	1 Con. C-90-12	20	140	53			600	9,495
	BD-5	6	28 6	20 8"	12 4'	102	2,454	4,400	2 Lyc. IO-540-B1A	110	320	62	800	800	1,270	72,900
	BD-7	20	55 4	62 4	20 8"	400	9,150	12,500	2 GE CT-58	472	350	81	850	850	2,100	300,000
Beech Aircraft Corp. Wichita, Kan.	Super H18	7-8	45 7"	35 2	8 3"	300	5,950	9,900	2 P&W R985-AN-14B	310	295	87	2,072	1,850	1,330	132,360
	Queen Air 80	6-7	45 3"	34 3"	8 6	277	4,990	8,000	2 Lyc. IGSO-540-AJA	180	282	76	1,450	2,070	1,330	135,000
	Queen Air 65	5-6	45 3"	33 3	14 2"	277	4,040	7,700	2 Lyc. IGSO-480-A1E6	180	230	80	1,350	1,585	1,220	125,000
	Twin Bonanza 50	6	45 0"	31 5	11 3"	277	4,450	7,500	2 Lyc. IGSO-480-A1E6	180	235	82 §	1,450	1,840	1,600	160,000
	Twin Bonanza D50E	6	45 0"	31 5	11 3"	277	4,300	6,300	2 Lyc. GO-480-G2E6	134	214	71	1,250	1,450	1,090	87,000
	Baron A55	4-5	37 9"	29 2	8 6	169	2,950	4,900	2 Con. IO-470-L	112	235	78	1,245	1,470	1,225	98,950
	Travel Air B95A	4-5	37 9"	24 3"	8 6	168	2,850	4,250	2 Lyc. IO-360-A1A	78	216	70	1,260	1,590	1,170	49,450
	Bonanza P35	5	33 4	26 2	8 6	181	1,972	3,125	1 Con. IO 470-N	49	205	60	1,060	840	1,215	27,650
	Debonair B33	4	32 8	26 5	8 3	177	1,745	3,000	1 Con. IO-470-K	49	193	60	1,235	1,282	1,135	23,500
	Musketeer M23	4	32 8	23 0	8 3	146	1,300	2,450	1 Lyc. O-320-D2 B	50	144	62	1,320	1,215	895	15,160
Cessna Aircraft Co. Wichita, Kan	150	2	35 8"	21 5	7 8"	160	950	1,500	1 Con. O-200A	26	127	49	680	350	610	7,778
	172	4	36 2"	26 5	8 9"	174	1,260	2,300	1 Con. O-300-C	42	138	45	885	620	720	10,248
	172/Powermatic	4	36 2"	26 5	8 9"	174	1,300	2,300	1 Con. GO-300-E	42	146	54	800	810	610	13,275
	Skyhawk	4	36 2	26 5	8 9"	174	1,330	2,300	1 Con. O-300-D	42	150	49	850	520	720	11,995
	Skyhawk/Powermatic	4	36 2"	26 5	8 9"	174	1,425	2,300	1 Con. GO-300-E	42	148	54	800	810	615	14,650
	180	4	36 2"	23 5	7 8"	174	1,336	2,650	1 Con. O-470-R	69	170	56	555	350	1,215	15,950
	182	4	36 2"	27 3"	9 0"	174	1,444	2,800	1 Con. O-470-R	58	167	59	925	590	1,160	16,450
	Skylane	4	36 2"	27 3"	9 0"	174	1,425	2,800	1 Con. O-470-R	69	170	59	625	390	1,215	18,990
	185	6	38 2"	25 8	7 6	174	1,580	3,200	1 Con. IO-470-F	55	178	62	940	470	1,235	16,405
	205	6	36 8	27 6"	9 0"	178 6	2,329	3,350	1 Con. IO-470-S	62	173	57	685	525	1,015	22,795
	210	4	36 8"	27 6"	9 0"	175 5	1,850	3,800	1 Con. IO-470-S	95	195	60	915	485	1,585	24,975
	310G	6	37 5	28 8	9 0"	170	3,013	5,100	2 Con. IO-470-D	102	240	75	920	580	1,350	62,850
	Skymaster 336	4-6	38 0"	29 6	9 3"	201	2,230	3,600	2 Con. IO-360-A	92 §	185	56	1,145	1,305	1,240	39,950
	Skyknight	6	37 0"	29 5	10 3"	175	3,237	5,250	2 Con. TSIO-470-R	102	263	76	1,110	880	1,400	74,850
Champion Aircraft, Inc. Osceola, Wis	7EC Traveler	2	35 2	21 7	8 2"	170	800	1,500	1 Con. C-90-12F	26	115	38	500	350	500	6,775
	7FC Tri-Traveler	2	33 2	21 7"	7 2	170	830	1,500	1 Con. C-90-12F	25	110	44	500	350	500	7,310
	7GCA Challenger	2	40 5	21 0"	8 2"	170 2	1,450	2,450	1 Lyc. O-320-A2B	35	128	45	750	350		8,990
	7HC DX er	5	33 6	21 9"	7 3"	184	1,000	1,650	1 Lyc. O-290-D2B	35	125	49	850	850	850	8,545
	402 Lancer	2	34 5	22 5	10 0"	170 2	1,700	2,400	2 Con. O-200	50	130	50	600	710	744	12,350
Grumman Aircraft Engr. Corp. Bethpage, N.Y.	159 Gulfstream	14	78 5	64 6"	22 8	918	20,434	32,500	2 R-R RDa 7/2	1,304	380	84	5,800	1,800	2,500	
	164 Ag Cat	1	35 7	24 3	10 0	326	2,170	3,500	1 Con. W-670	34	110					18,500
Helio Aircraft Corp. Norwood, Mass	H295A Courier	3	39 0"	30 0	8 5	231	2,500	3,000	1 Lyc. GO-435-C2B2	60	136	30	600	425	900	35,500
	H395 Super Courier	5	39 0"	30 0"	8 5"	231	2,687	3,000	1 Lyc. GO-480-G1D6	60	150	30	475	400	842	38,500
	H500 Twin	6	41 0	30 3	8 6"	242			2 Lyc. O-540							
Jamison Corp. De Land, Fla	Take 1	4	29 0'	21 6"	7 2"	138 2	890	1,880	1 Lyc. O-320	30		51			850	8,485
Lake Aircraft Corp. Sanford, Me.	Lake LA-4	4	38 0'	28 0'	9 3"	170	1,675	2,600	1 Lyc. O-360	40	131	50	625	420	927	20,500
Lear Jet Corp Wichita, Kan	Lear-Jet	6	35 8	41 8"	13 1			12,500	2 GE CJ610-1		550				1,000	489,000
Lockheed Aircraft Corp. Marietta, Ga.	1329 Jet Star	10	54 4	60 4	20 5	543	19,000	35,000	4 P&W JT12A-8	5,623	570	125	5,000	4,300	2,950	
	Lockheed 60*	6	36 3	22 1	10 7	210	2,024	2,532	1 Con. TSIO-470-B		187	58	1,045	1,045	850	25,000
Mayaro Aircraft Co. Tecumseh, Mich	Mayaro 295B	4	30 5	24 4	8 8"	181 6	1,948	3,600	1 Con. IO-470D	40	200	62			500	24,040
Mooney Aircraft, Inc. Kerrville, Tex	Mark 21	4	35 0'	23 2"	8 3"	167	1,525	2,575	1 Lyc. O-360	48	150	57			952	18,450
	Master M 20-D	4	35 0'	28 2	8 3	167	1,425	2,325	1 Lyc. O-360-A1D	48	147	57	800	850	800	18,995
Piper Aircraft Corp. Lock Haven, Pa	PA 22-108 Colt	2	30 0"	20 0"	6 3"	147	840	1,650	1 Lyc. O-234-C1E	18	120	54	850	500	5 455	5 495
	PA-18-150 Super Cub	2	35 3	22 4"	6 0	178 5	950	1,750	1 Lyc. O-320	50	130	48	900	550	600	6,900
	PA-25-150 Pawnee	1	36 2"	24 0"	6 7	183	1,200	2,200	1 Lyc. O-320-A2B	40	113	45	985	400	440	11,400
	PA-25-235 Pawnee	1	36 2"	24 7	7 2"	183	1,380	2,950	1 Lyc. O-540	40	127	45	800	400	325	13,900
	PA-28-150 Cherokee	4	30 0"	23 6"	7 3"	160	1,182	2,150	1 Lyc. O-320-A2B	50	138	53	880	535	780	10,900
	PA-28-160 Cherokee	4	30 0	23 3"	7 3"	160	1,196	2,200	1 Lyc O-320-E2B	50	138	56	775	550	800	11,500
	PA-28-180 Cherokee	4	30 0"	23 8	7 3"	160	1,268		1 Lyc. O-360-A2A	50	150	57	775	600		12,500
	PA-24-180 Comanche	4	35 0"	24 7	7 3"	178	1,510	2,550	1 Lyc. O-360	50	167	62	750	600	920	17,950
	PA-24-250 Comanche	4	30 0"	24 0	7 3"	178	1,630	2,900	1 Lyc. O-540-A1A5	60	190	61	780	650	1,100	21,990
	PA-23-235 Apache	5	37 6"	27 6"	10 3"	207	2,580		2 Lyc. O-540-B1A5	144	204	58	950	900		44,960
	PA-23-250 Aztec B	1	37 0"	30 1	10 3"	207	2,900	4,800	2 Lyc O-540	144	215	59	750	660	1,450	52,950
Wren Aircraft Corp Fort Worth, Tex	Wren 460	4	36 2"	27 3"	10 3	175	1,565	2,800	1 Con O-470-R	88	190	55	550	350	1,160	29,950

* International production.

Leading International Ground Effect Machines

Manufacturer	Vehicle Name	Seats, inst. pilot	Length, ft.	Width, ft.	Height, ft.	Empty Weight, lb.	Max Gross Weight, lb.	Powerplant Quantity Manufacturer Model and Power Rating	Max. Speed, mph	Cruise Speed, mph	Hover Height, in	Endurance, hr.	Remarks
UNITED KINGDOM													
Cushioncraft Ltd. *Bembridge Airport Isle of Wight*	CC-2 Series 1	1 2 0	17	8 3	3 500		5 000	1 x Rolls-Royce LV-8	42		18	3	Commercially available. Designed for operation over rough terrain
	CC-2 Series 3	1 2 0	17	8 5	3 700		6 000	1 x Rolls-Royce LV-8 + 2 x Rollason Ardem @ 90 hp.	90		12	3	
Vickers-Armstrong Ltd *South Marston Swindon Wilts*	VA 1	5 2 5	14 5	15			5 750	1 x BS Gipsy Major + 2 x Continental 0-300-B @ 135 hp.	45		4 9	1 5	R&D vehicle.
	VA 2	3 2 0	3 13	10 7			5 000	2 x Continental 6-300 B @ 135 hp. + 1 x Continental 0-470 L @ 220 hp.	70	40	5	1 5	
	VA-3	26	54 5	28 5	17 5		30 000	4 x BS Turmo 605 @ 425 shp.	80	70	8	1 3	First scheduled GEM passenger ferry service
Westland Aircraft Ltd. *Yeovil, Somerset*	SRN3 Hovercraft Mk. 1	78	64 5	29 5	23 3	32 500	54 000	4 x BS Nimbus @ 515 shp.		80	12-15	2 9	Has been used in over water passenger service.
	SRN2 Hovercraft Mk. 2	109	70 5	39 5	27 5		73 000	4 x BS Nimbus @ 885 shp.		86	12-18	3 1	
UNITED STATES													
Aerospace Div. of Ford Motor Co. *Newport Beach Calif*	FMC/ACV-1	2 2 1	8	8		4 000	7 000	2 x Continental @ 310 hp.		40	2-3	2 5	Uses flexible skirt to confine air curtain.
Bell Aerosystems Co. *Buffalo 5 N Y*	BKMR-1 Hydroskimmer	5	65	29	20	45 000	54 000	4 x Solar Saturn @ 1,060 hp.		90	15-18	1 73	Being developed under Navy Contract. Under development for Port of New York Authority
	Bell/PSVA ACV	3	27	14	11		3 000	1 x 330 hp.; 1 x 180 hp.	70		12		
Aerospace Division Martin Marietta Corp. *Orlando, Fla.*	Ejectijet	1	20	18	3		8 400	AiResearch gas turbines	20		12		
National Research Associates, Inc. *Laurel, Md.*	GEM No. 1	3	14	8	5 5		1 200	2 x Triumph motorcycle engines @ 40 hp.	58	38	5-15		Similar to PASS vehicle developed by Tank Corps. Delivered to USMC. Air cushion boat. Eight-speed cargo and utility GEM said to be in production
	GEM No. 3	1	22	12	10	1 335	3 500	2 x Solar YT62 Titan @ 80 shp.	30		18		
	Aqua-Gem	6	28	8	9	2 200	3 200	2 x Wetbird @ 40 hp	60		1-2		
	Air Carrier	15	50	8 5		1 700	3 200	1 x 40 hp. + 1 x 80 hp	30		3	160-mi. range	
Reynolds Metals Co./Welland	Everglades Speedster	4	31	14	10		4 000	1 x Lycoming 0-340-A1E @ 160 hp.	75		7		Directional control by large rudder in propeller slipstream

U. S. Drones

Prime Contractor	Military designation	Mission	Agency	Overall length, w/o booster ft.	Overall span (wings or fins), ft.	Body diameter ft.	Launch weight, w/o booster, lb.	Powerplant No. of Eng. Manufacturer Eng. designation	Guidance Manufacturer	Guidance Type	Performance Speed, mph	Performance Endurance, min	Remarks
Aerojet General Corp. *Azusa, Calif*	SD-2	Multi	Army	15 0"	13 3"		5 125	1 Lyc LMO-360 A10	ITT	Radio command	349	48	2 Jato boosters
Beech Aircraft Corp. *Wichita Kan.*	1025/KDB-1	Trans.	Army/ Navy	15 1"	13 1"	1 5	565	1 McCulloch IC-6130-J-1 turbo supercharged		Radio command	340	90	Recoverable
	KD2B-1/ Q12	Trans.	Navy/ USAF	13 3"	3 3"	1 1	371	1 Rocketdyne LR-64 NA4 liquid bipropellant rocket		Programmed or Radio control	M 3	15	Air Launched, surface launch under development
	1025-TJ (turbojet)	Train.	Army	17 0"	12 1	1 8"	1 061	1 Con. Model 361-1 turbojet		Radio command	470	70	Recoverable
Del Mar Engineering Laboratories *Los Angeles Calif*	DH-1E Whirlymite	Recon		18 3"			400	1 Kiekhaefer Mercury 900			74		Helicopter drone
	DH-2B	Recon		18 3"			345	1 Solar Titan T62-T-13			77		Helicopter drone
Gyrodyne Co. of America *St James N Y*	QH-50A	Anti-sub	Navy					1 Gyrodyne Porsche					Helicopter drone for Navy's destroyer carried DASH program
	QH-50B	Anti-sub	Navy					2 Gyrodyne Porsche					
	QH-50C	Anti-sub	Navy					1 Boeing T50-BO-4		Digital data link			
Ling-Temco-Vought, Inc. *Dallas, Tex*	KD2U-1 Regulus 2	Target	Navy	57 0"	20 0"	5 0"		1 GE J79 with aft. burner plus Aerojet 116,000 lb. boost					
Lockheed Aircraft Corp. *Burbank, Calif*	QR-47	Target	USAF	109 8"	115 0"			5 GE J47-GE 25		Radio command	495		Boeing airframe
	QF-104	Target	USAF	54 6"	21 0"			1 GE J79-3A		Radio command			F 104A conversion for missile evaluation.
North American Aviation Inc. *Los Angeles, Calif*	NA-273	Train.	Army	15 0"	3 0"	1 0"	427	1 Marquardt Ramjet plus NAA Rocketdyne booster @ 5 500 lb. t	NAA, Columbus	Radio command	M 2		Redtop/Hi-sadranam: recoverable.
Northrop Corp. *Newbury Park Calif*	OQ-15	Target	Army	12 3"	11 5"		325	1 McCulloch 0100-1	Babcock Eng'g	Radio command	222	60	OQ-19D Q Army & USAF KD2R-5 Navy
	RP-76	Target	Army	9 7"	3 0"	1 0"	301	2 syc Avneo Chem. & BFC	Northrop	Radio command	M 53	23	RP 78-Navy & USAF
	SD-1	Surv*	Army	13 4	11 9"		430	1 McCulloch	Babcock	Radio cmd.	130	40	*Surveillance
Republic Aviation Corp. *Farmingdale, N Y*	Bikini	Recon.						3 cycle 2 cyl.	Republic	Radio command	115	30-40	Battlefield-launched by 2 men
Ryan Aeronautical Co. *San Diego Calif*	KDA-1 Firebee	Target	Navy	17 3"	11 2"		1 835	1 Fairchild J44 R 20			530	90	
	KDA-1 Firebee	Target	Navy	17 3"	11 2		1 848	1 Fairchild J44 R 20			533	90	
	Q-2A Firebee	Target	USAF	17 3	11 2"		1 848	1 Con. J69 T 16			530	90	
	XQ-2C Firebee	Target	USAF	22 3	12 6"	3 8"	2 500	1 Con. J69-T-29	Lear	Radio-Radar	M 98	96	
	Q-2C Firebee	Target	Navy/ USAF	22 5"	12 6"	3 8"	2 500	1 Con. J69 T 29	Lear	Radio-Radar	M 98	96	Also used by Army with 124-E designation

USSR Military and Civil Aircraft

● SPECIFICATIONS

Designation	NATO Code name	No. of crew	Overall span ft.	Overall length, ft.	Gross weight, lb.	No. designation and max. power each engine	Max. speed, mph	Service ceiling, ft.	No. and type weapons	Remarks
	Blinder	3	70	130	176 000	2 x rearmounted axial tj	1 300	50 000	ASM	Formerly called Beauty & Bullshot. Extensive photo equip. indicates strike/recon. aircraft
	Bounder		80	197	300 000	4 x D-14 tj @ 28,660 lb. t.	700	55 000		Subsonic cruise, based on engine test bed and tanker. Joint production Vladimir Myasischev design
M-4	Bison		170	140	250 000	4 x AM 209 tj @ 19,500 lb. t.	610	45 000		Equipped for aerial refueling
Tu-95	Bear		180	150	330 000	4 x NK 12 @ tp 12 000 shp.	550	50 000	ASM	Range about 8 000 mi.; modified to carry 1 000 mi. range missile
Tu 16	Badger		100	105	180 000	2 x AM-500 tj @ 19,500 lb. t.	600	50 000	ASM	Modified to carry 480 mi. range missile. Sold to Indonesia and UAR.
Yak-25	Flashbar	3	40	55	30 000	2 x tj @ 8,000 lb. t.	800	50 000		Mod. fed. w. radome & ventral fins. Formerly called Flashlight B. In production.
Yak-42	Backfin	3	80 4	101 7	88 800	2 x AM 209 @ 20 240 lb. + aft	800	50 000		Experimental prototype; flow sweep. 1957
Il-36	Blowlamp	2	67	70		2 x tj @ 17 000 lb. t.	750	50 000		55 deg. wing sweepback
B-29	Beagle	3	68	62	44 000	2 x RD-45 tj @ 5 000 lb. t.	600	45 000	2 x 23 mm	Satellite production and use deployed to Cuba.
									2 x 12.7-mm	
Be-10	Mallow	0				2 x tj @ 11,300 lb. t.	570	35 000	ASW detection, attack gear	Flying boat.
Be-6	Mail					2 x tp @ 5 600 ehp			MAD gear for ASW detection	Gull wing flying boat.
Tu-14	Bosun	0	70	65	50 000	2 x VK-1 tj @ 5 000 lb. t	500	40 000		Navy torpedo bomber
Yak-7	Fiddler	2	72	120	150 000	2 x shoulder mtd. axial tj.	1 300	60 000	AAM	Long range interceptor w. large swp. & intercept. radar. Formerly called Mixter.
Yak-25	FlashFight A	2	40	55	30 000	2 x tj @ 7 500 lb. t.	700		3 x 37 mm	Standard operational all-weather fighter
Yak-25	Flashlight C	2	40	55	30 000	2 x tj @ 8 500 lb. t.	620	50 000	Missiles	Advanced version of Flashlight A
MiG-25	Flipper	1	45	85		2 x axial tj + rocket	1 700	95 000	AAM	Delta swag; large airborne radar. Two-stage 50-ton missiles. FAI 100 km. world record average 1 481 mph
MiG-23	Faceplate	1	33	50		1 x axial tj @ 22,000 lb. t.	1 200	60 000		Operational.
MiG 21	Fishbed	1				1 x axial tj @ 22,000 lb. t.	1,200	60 000	AAM	Operational in USSR, Hungary, Poland, East Germany, Cuba. Sold to India.
MiG 19	Farmer	1	30 9"	44 3"	27 000	2 x VK 7 ax tj @ 8,800 lb. t. +aft.	900	58 000	2 x 23-mm.	Low-set stab. tail; deployed to China, Poland, Hungary, E. Germany, Egypt, Iraq & Indonesia.
MiG17	Fresco	1	33	37	15 000	1 x VK-1A tj. @ 5,950 lb. t.	700	51 000	2 x 23-mm.	Sabre reproduction and use manufactured 10,000 built
Su 15	Flitter	1				1 x axial tj. @ 22,000 lb. t.	1 000		Rockets	Competitor to Faceplate; not in production; used area rule
Su 10	Fishpot	1	25	50		1 x axial tj @ 22,000 lb. t	1 200	60 000	AAM	Delta 50 m. dia. tailpipe all weather in production.
Mi 10	Harke	3	115			2 Soi. @ 4 700 shp.				Flying crane fitted 33 702 lb. payload to 7 200 ft.—FAI record
Mi-8	Hip						194			Turbine powered development of Mi-4. 28 passengers.
Mi-6	Hook	2			86 000	2 x Soi @ 4 700 shp	195			Held FAI 100 km. speed record 183.5 mph; has carried 24 000 lb. payload to 7,500.
Mi 4	Hound	2	69'		12 015	1 x ASh-82V @ 1700 hp.	130	11 800	None	Aeroflot uses 10 place Mi-4P. Sold to India.
Mi-3		4	47'	70	9 150		124			Mi 1T development
Mi-2		1				2 x Izvhenhuk.				Turbine powered development of Mi 1, 8 passengers.
Mi 1	Hare	4	46' 6"		4 938	1 x AI 26B @ 575 hp.	103	14 700		Range 400 miles.
Ka-22	Bossp	2	100'			2 Ivchenko gas turbines @ 5 700	227 42			Twin rotor, twin-prop. convertiplane; holds FAI convertiplane speed record
Ka-20	Harp	2				2 x axial tj.			ASW	ASW role radar
Ka 18	Hog		32' 8"		2 866	1 x AI-14WF @ 275 hp.	150	11 500		Coaxial rotor. 4 passengers.
Ka-15	Hen		32' 8"			1 x AI-14 @ 260 hp.	93	9 000		Coaxial rotor. 2 passengers.
Ka-10	Hat	1			440	1 x AI-4G @ 55 hp.		8 000		Coaxial rotor
Yak 24	Horse	4	80'	75	33 000	2 x ASh-82F @ 1 490 hp.			None	Flight test rivet operative transport for Aeroflot designated Yak 24K
Yak 24A	Flying Bus				28 365	2 x ASh-82F @ 1 400 hp.	100	18 000		
An-24	Coke	9	60	80' 4"	41 300	2 x Ivchenko tp. @ 2,000 shp	348	20 000		Operates from sod and dirt runways.
An-10				131		4 x NK & AI tp @ 4 000 shp	328		None	150 passengers, similar to An 10
An-14	Clod	1	66	36	7 080	2 x AI-14R @ 260 hp.	143	16 100	None	STOL class. Little Bee
An-12	Cub	3-5	124 8"	121 4"	121 500	4 x NK&AI tp. @ 4,000 shp.	480	30 000	Tail turret	Military, rear load. tp version of An 10. Sold to Ir. Ja. and Ghana.
An-10	Cat	3-5	124 8"	121 4"	121 500	4 x NK&AI tp. @ 4,000 shp	480	30 000		85 passengers. An 10A carries 100. also a cargo version.
An-8	Camp				77 160	2 x NK tp. @ 1 000 shp.			Tail turret	Assault transport. Aeroflot freighter
An-2	Colt	2	84	35	11 000	1 x ASh-62IR @ 1,000 hp.	137	37 989	None	Biplane
Il-62	Classic		168			4 x NK-11 @ 23 000 lb. t	590			Long range 182 passenger transport.
Il-18	Cant	3-5	122	117	124 500	4 NK&AI tp. @ 4 000 shp.	400	36 000	None	75-100 passengers. 3 600 mi. range. Polish, Czech, Aeroexpress airlines
Il-14	Crate	2-3	104	70	32 400	2 x ASh-82T @ 1,500 hp	200	1-000	None	Mil-built version in India, UAR
Il-14M	Crate	2-3	104	70	36 460	2 x ASh-82T @ 1 900 hp	207		None	24 passenger version
Il-12	Coach	3-5	101	70	38 000	2 x ASh-82T @ 1 850 hp.	232		None	USSR, Polish, Czech airlines.
Tu-124	Cookpot				240 000	2 x Soi II @ 8 500 lb. t	520	35 000		Medium-range transport
Tu-114	Cleat	4	177	154	396 900	4 x NK-12M tp @ 12 000 shp.	550	55 000	None	Moscow-Khvani nonstop.
Tu 114D			180' 6"		249,000	4 x NK-12M tj @ 12 000 shp.				
Tu-104	Camel	3	114	121	120 152	2 x AM-209 tj @ 11 850 lb. t	560	39 000	None	ICAO range, 1 988 mi.
Tu 104A	Camel A	3	113	127	165 000	2 x AM-3 tj @ 18,000 lb. t	600		None	70 passengers.
Tu 104B		3	144	124 5"	165 000	2 x AM-3 tj. @ 18 000 lb. t.	530			100 passengers.
Tu 104E		3				2 x Turbofans @ 25,000 lb. t.	621			120 passengers.
Tu-70	Cart	4	141	118		4 x ASh-82FNV @ 1 850 hp.	215		None	Tu-4 commercial (B 29) copy
Li 2	Cab	2	95	64		2 x M-62R @ 1,000 hp.				USSR built Douglas DC-3.
Yak-32	Mantis	2				1 x Turumansky ax tj				Tricycle gear
Yak 18A	Max	2	34 8"	28		1 x radial piston	161	16 897		Tricycle gear
Yak-18P		3	34 8"	27	2 348	1 x AI 14R @ 260 hp.	171	21 329		

Abbreviations
AAM—Air-to-Air Missile
AM—A. A. Mikulin
ASh—A. D. Shvetsov
ASM—Air-to-Surface Missile
Il—Sergei Ilyushin
Al—A. G. Ivchenko
Ka—Nicolai Kamov
M—Mikoyan (old designation)
MiG—Artem Mikoyan & Mikhail Gurevich
Mil—Mikhail Mil
NK—N. D. Kuznetsov
Soi—Solovev
Su—Pavel Sukhoi
tf—turbofan engine
tj—turbojet engine
tp—turboprop engine
Tu—Andrei Tupolev
VK—V. Klimov
Yak—Alexander Yakovlev
zft.—afterburner
' Rotor Diameter

Leading International Gas Turbines

Manufacturer and Address	Designation	Type	No. of compressor stages	No. of turbine stages	No. of combustors	Max. power @ S. L.	Specific fuel consumption at maximum power	Compression ratio at max. rpm	Maximum envelope diameter, in.	Maximum envelope length, in.	Dry weight, less tailpipe, lb	Remarks
CANADA Orenda Engines, Div., Toronto, Ontario	Orenda 10	AFJ	15	1	8	6 348 lb. t.	1 12	5 3	42	123	2 515	
	Orenda 11	AFJ	10	2	8	7 275 lb. t.	0 95	5 1	45	121	2 428	
	Orenda 14	AFJ	10	2	8	7 275 lb. t.	0 98	5 1	45	181	2 425	
	J75 OEL-7*	AFJ	17	3	16	15 000 lb. t.		12	78 33	204	3 200+	*CF 104—limit under license
	J79-11A*	AFJ	17	3	10	18 000 lb. t.		12	38 21	204	3 200+	
	J85-Can 40	AFJ	8	2	1	3 000 lb. t.	0 90	7 1	17 7	90 5	365	Canadair CF-114 Tydee
GREAT BRITAIN HAWKER SIDDELEY GROUP Bristol Siddeley Engines, Ltd. Filton	Artouste 510	CFJ	1	2	1	220 shp.	338+lb/hr	7 5	18 1	37	235	+Actual fuel consumption
	Astazou 2	ACFP	1-1	2	1	523 shp.	0 52	6 5	18 1	69	271	Short Skyvan
	Astazou 5	ACFP	1 1	2	1	562 shp.	0 53		18 1	69	271	
	Ambusne	AFF	1 1	2	1	1 575 lb. t	0 0	7 0		91 5	495	
	Cumulus	CFG	1	2	1	320 shp		2 65	17 7	34 1	210	
	Double Mamba 5	AFF	11	2	24	3 600 shp.	0 0	5 5	81 38	103 30	2 500	Gnocel
	Gnome H 1000	AFS	10	1	1	1 050 shp.	0 4	8 30	15 6	55	295	GET 55 6 squre Whirlwind 10 Agusta 2040 & 1010
	Gnome H 1200	AFS	15	1	1	1 350 shp.	0 2	8 35	15 6	55	314	GET 58-6 squre
	Gnome P 1200	AFP	15	1	1	1 150 shp.	0 5	8 30	31 5	90	615	Turboprop version of H 1000
	Coupled H 1000	AFS	10	2	1-1	2 300 shp.	0 2	8 30	41 8	77 13	973	Wessex Mk. 2 1,200 shp. u individual engine output at gearbox input.
	Gyron Jr DGJ 2	AFJ	2	8	1	7 100 lb. t.			32 3	121 1	2 166	Buccaneer 1
	Gyron Jr DGJ 15	AFJ	2	8	1	14 000 lb. t.			32 3	101	3 100	Bristol T 188
	Nimbus 750 (Series)	ACFJ	2	1	1	930 shp. (1 hr.)	0 8	0 0		62	330	Westland Wasp & Scout
	Olympus 104	AFJ	7 & 8	1 & 1	10	13 000 lb. t.			42 4	132	3 516	Avro Vulcan Mk. 1
	Olympus 201	AFJ	5 & 7	1 & 1		17 000 lb. t.			41 7	126 4	3 650	Avro Vulcan Mk. 2
	Olympus 301	AFJ	5 & 7	1 & 1		20 000 lb. t.			42 0	168 5	3 800	
	Supersonic Olympus	TJ	CIVIL AND MILITARY VERSIONS UNDER DEVELOPMENT FOR SUPERSONIC APPLICATIONS									
	Olympus 2001	Ind	5 & 7	1 & 1	8	23 000 shp.	52			312	38 005	15 Megawatt generator, in- dustrial
	Olympus 2002	Ind	5 & 7	1 & 1	8	22 005 shp.	52			288	16 005	Frigates hydrofoils GEMs etc
	Orpheus 701	AFJ	7	1	7	4 700 lb. t	1 057	4 30	32 4	73	790	Folland Gnat
	Orpheus 703	AFJ	7	1	7	4 850 lb. t	1 045	4 50	32 4	75 5	825	HF -24
	Orpheus 603	AFJ	7	1	7	5 000 lb. t.	1 05	4 38	32 4	90 1	900	G91 Eendard VI Tano
	Orpheus 803	AFJ	7	1	7	4 000 lb. t.	1 04		32 4	75 5	825	FIA Trainer FUJI
	Orpheus 101	AFJ	7	1	7	4 230 lb. t.	1 00	4 30	32 4	77 5	800	Gnat Mk 1 Jet Trainer
	B. OR. 12	AFJ	8	2	7	9 810 lb. t	0 67	5 50	32 4		1 170	
	B. OR. 12 (SR)	AFJ	8	2	7	8-170 lb. t.	1 62	5 60	32 4	191 4	1 150	Afterburner Base Thrust 8815 lbs.
	Palas 600	AFJ	1	1	1	930 lb. t.	1 20	4 12	10 5	46	170	
	Palouste 502	CFJ	1	2	1		300 lb./hr.		15 1	34	215	Canadair CL 66 Ground Starting Units
	Palouste 600	CFJ	1	2	1			3 81	10 1	34	214	
	Pegasus	AFL	UNDER DEVELOPMENT FOR V/STOL APPLICATIONS									
	Proteus 706	ACFP	5 & 13	2-2	8	14200 lb. t.		6 5	7 2	123	3 005	Britannia 102
	Proteus 701	ACFP	1-12	2-2	8	4 395 shp.		5 0		123	2 900	
	Proteus 705	ACFP	1-12	2-2	8	4 250 lb. t.		5 0	7 3	123	2 960	Br. 200 200-315 320
	Proteus 1277	Ind	1-12	0-2	8	2.84 MW				100	3 050	3 MW Generator, industrial
	Proteus 1276	M	1-12	2-2	8	4 250 shp.		575		112	2 888	*Brave Bordercr Class, Marine
	Sapphire 100	AFJ	15	2	24	6 200 lb. t.		6 00	7 40	100 5	2 670	Javelin
	Sapphire 800	AFJ	13	2	24	11 000 lb. t.		8 8	7 40	107 7	3 080	Javelin, Victor
	Sapphire 200 (7E)	AFJ	13	2	24	12 235 lb. t.		1 2	7 40	107 7	3 100	Limited A/B Javelin
	Turmo 601	CFJ	2	3	1	400 shp.		4 62 lb/hr	5 5 19 23	47	225	V A 3, Hovercraft
	Turmo 602	CFJ	2	3	1	425 shp.			5 5 15 25	49	275	
	Turmo 603	CFJ	2	2	1	425 shp. (1 hr.)		1 10	5 5 10 25	49	313	
	Viper 8	AFJ	7	1	24	1 750 lb. t.		1 07	4 0 24 3	67	510	Provost Mk 3
	Viper 9	AFJ	7	1	24	1 600 lb. t.		1 12	4 25 24 3	67	510	HP 115.
	Viper 11	AFJ	7	1	24	2 600 lb. t.		1 07	4 21 24 5	84	545	MB. 326 Macchi. Jet Provost Mk 304
	Viper 12	AFJ	7	1	24	2 700 lb. t.		1 10	4 42 24 5	84	549	Uprated ASV 11
	Viper 20	AFJ	8	1	24	3 000 lb. t.		985	5 09 24 5	88 7	575	D H 125. FD 808
	R. S. 196		UNDER DEVELOPMENT									
Rolls-Royce, Ltd. Derby	Avon RA 24R	AFJ	NA	NA	8	14,430 lb. t.*		NA	NA	41 8	126	NA	*Nominal performance
	Avon RA 29/1 Mks 522 525, 522A 526A	AFJ	10	3	8	15 500 lb. t		0 730	9 1	39	126	3 328	
	Avon RA. 29/1 Mk 524B & 526B	AFJ	10	3	8	10 250 lb. t		0 740	9 08	39	126	3-343	
	Avon RA 26/3 Mk. 527	AFJ	10	3	8	11 500 lb. t		0 718	8 36	39	126	3 347	
	Avon RA 26/8 RK 531	AFJ	17	3	8	12 200 lb. t.		0 724	10 1	39	134	3 493	
	Avon RA 29/6 Mk 932R	AFJ	17	3	8	12 040 lb. t		0 731	10 1	39	134	3 489	
	Avon RA 29/6 Mk. 933R	AFJ	17	3	8	12 500 lb. t		0 724	10 1	39	134	3 491	
	Avon RB. 146R	AFJ	NA	NA	8	18 000 lb. t.*		NA	NA	41 5	145	NA	*Nominal performance
	Conway R. Co 11	AFF	NA	NA	10	17 250 lb. t.		NA	NA	42	130	NA	
	Conway R Co 12 Mks, 508 & 509	AFF	7X5	3X1	10	17,500 lb. t.		0 600	11 1	42	130	4 542	
	Conway R. Co 17	AFF	NA	NA	15	20 000 lb. t.		NA	NA	42	135	NA	
	Conway R. Co 42	AFF	7X9	2X1	10	20 370 lb. t.		0 603	14 8	50	154	5 001	
	Conway R. Co 43	AFF	7X5	2X1	15	21 825 lb. t.		0 593	15 8	50	154	5 101	
	Dart R. Da. Mk. 506	CFP	2	2	7	1 345 shp.		0 760	5 4	36	98	1 025	
	Dart R. Da. Mk. 510	CFP	2	2	7	1 635 shp.		0 726	5 4	36	98	1 105	
	Dart R Da 0 Mk. 511 & 511-7E	CFP	2	2	7	1 835 shp.		0 750	5 4	36	98	1 088	
	Dart R. Da. 0 Mk 514	CFP	2	2	7	1 715 shp.*		0 000	5 4	36	98	1 114	*Water methanol restoration
	Dart R. Da. 7 Mk. 525	CFP	2	3	7	1 950 shp.		0 710	5 0	36	98	1 237	
	Dart R. Da. 7/1 Mk. 528	CFP	2	3	7	1 730 shp.		0 705	5 5	36	98	1 277	
	Dart R. Da. 7/2 Mks. 528 & 527	CFP	2	3	7	1 835 shp.		0 695	5 0	28	98	1 227	

(Continued on p. 215)

Leading International Gas Turbines

Manufacturer and Address	Designation	Type	No. of compressor stages	No. of turbine stages	No. of combustors	Max. power @ S. L.	Specific fuel consumption at maximum power	Compression ratio at max. rpm	Maximum envelope diameter, in.	Maximum envelope length, in.	Dry weight, less tailpipe, lb.	Remarks
Rolls Royce Ltd. *Derby* (Cont.)	Dart R. Da. 7/2 Mks. 528-7 & 528-7E	CFP	2	3	7	1,835 shp.	0.605	5.6	38	98	1,223	
	Dart R. Da. 7/2 Mks. 529-7 & 529-7E	CFP	2	3	7	1,910 shp.	0.656	5.6	38	99	1,223	
	Dart R. Da. 7/2 Mks. 529-8 & 529-8E	CFP	2	3	7	1,910 shp.	0.656	5.6	38	99	1,235	
	Dart R. Da. 7/2 Mks. 530 & 531	CFP	2	3	7	1,835 shp.	0.665	5.6	38	98	1,227	
	Dart R. Da. 10/1 Mk. 540-10	CFP	2	3	7	2,750 shp.*	0.630	6.35	38	98	1,377	*Water methanol restoration
	Dart R. Da. 2/7 Mk. 21	CFP	2	3	7	1,810 shp.	0.650	5.6	38	98	1,258	
	Dart R. Da. 8 Mk. 101	CFP	2	3	7	3,470 shp.*	0.632	5.8	38	98	1,207	*Water methanol restoration
	RB. 108	AFJ	8	2		2,200 lb. t.*		5.25	20.8	48.8	270	*Nominal performance
	RB. 145	AFJ	NA	NA		2,750*	NA	NA	22.0	50.0	NA	*Nominal performance
	RB. 162	AFJ	NA	NA	NA	4,400 lb. t.	NA	NA	31.0	25	275	
	RB. 168	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	
	Spey R. Sp. 1 Mk. 505-5/10 & Mk. 505-14	AFF	4×12	2×2	10	9,850 lb. t.	0.540	16.8	37	110	2,200	
	Spey R. Sp. 1 Mk. 509	AFF	4×12	2×2	10	9,850 lb. t.	0.545	16.8	39	110	2,290	
	Spey R. Sp. 3 Mk. 506	AFF	4×12	2×2	10	10,110 lb. t.		16.0	39	110	2,215	
	Spey R. Sp. 3W Mk. 505-5W & 506-14W	AFF	4×12	2×2	10	10,410 lb. t.		16.0	39	110	2,278	Water injection
	Spey R. Sp. 4 Mk. 310	AFF	5×12	2×2	10	11,000 lb. t.			39	115	2,312	
	Tyne R. Ty. 1 Mk. 506	AFP	6×9	3×1	10	4,320 shp.	0.485	13.0	43.2	108.7	2,275	
	Tyne R. Ty. 11 Mk. 512	AFP	6×9	3×1	10	4,850 shp.	0.471	13.0	43.2	108.7	2,275	
	Tyne R. Ty. 12 Mk. 512	AFP	6×9	3×1	10	5,095 shp.	0.455	13.5	43.2	108.7	2,177	
	Tyne R. Ty. 12 Mk. 101	AFP	6×9	3×1	10	5,095 shp.	0.455	13.5	43.2	108.7	2,210	
	Tyne R. Ty. 20 Mk. 21	AFP	6×9	3×1	10	5,440 shp.	0.445	13.5	43.2	108.7	2,293	
	Tyne R. Ty. 20 Mk. 60	AFP	6×9	3×1	10	5,440 shp.	0.446	13.5	43.2	108.7	2,218	
FRANCE Hispano-Suiza *Paris*	H. S. Verdon	CFJ	1	1	9	7,700 lb. t.	1.10	4.9	60	164	2,072	
	H. S. Tyne	AFP	6+9	1+3	10	6,100 tehp.	0.439	17.0	43.2	108.7	2,107	
S.N.E.C.M.A. *Paris*	Atar E5	AFJ	8	1	A	8,160 lb. t.	1.03	4.8	39.4	181.8	2,130	
	Atar G3	AFJ	8	1	A	9,700 lb. t.	2.05	4.8	39.4	230	2,710	Afterburner
	Atar 08B	AFJ	9	2	A	9,700 lb. t.	0.98	5.5	36.2	160	2,295	
	Atar 09B	AFJ	9	2	A	13,210 lb. t.	2.20	5.5	40	247	2,910	Afterburner
	Atar 09C	AFJ	9	2	A	13,620 lb. t.	2.03	5.7	40	234	3,025	Afterburner
	Atar 09K	AFJ	9	2	A	15,435 lb. t.	2.10	6.0	40	234	3,153	Afterburner
	TF 106	AFF	16	4	8	16,845 lb. t.	0.25		50	187.4	3,390	Afterburner
Societe Turbomeca *Paris*	Artouste 2C	CFS	1	2	A	500 eshp	.87	3.88	1.8	4.72	253	Alouette 2 Sud Aviation helicopter
	Artouste 3B	ACFS	2	3	A	500 eshp.	.68	5.20	1.8	4.80	287	Sud Aviation SE3160
	Astazou 2	ACFS	2	3	A	554 eshp.	.60	6.00	1.5	4.98	260	Sud Aviation Alouette-Agusta
	Astazou 3	ACFS	2	3	A	562 eshp	.60	6.00	1.5	6.76	271	Dornier DO 27 Beech "SFERMA 'Marquis'" Potez 840-Nord 1110-SIPA 251
	Aubisque		3	2	A	1,550 lb. t.	.60	6.0	1.9	3.78		SAAB 105
	Antan 5		4	2	A	5.52 lb./sec.	422 lb/hr	4.2	0.0	4.33	287	
	Bastan 4	ACFP	2	3	A	1,000 eshp.	.61	5.5	1.8	6.20	463	Morane Saulnier 1500-Sud Aviation Voltigeur "Diamante"-SFERMA PD 185-Beech 18 S-Max Holste Super Broussard GAM Dassault 415 410
	Bastan 6		2	3	A	1,100 eshp.	.59	6.0	7.5	6.20	498	Nord Aviation MH 262 Super Broussard
	Bi-Bastan		2	3	A	1,800 eshp.	.65	5.8	3.4	9.00	900	Sud Aviation S-68 helicopter
	Gabizo	ACFJ	2	2	A	2,420 lb. t.	1.05	5.2	2.2	6.93	585	
	Gourdon	ACFJ	2	1	A	1,500 lb. t.	1.04	5.2	1.9	6.75	678	
	Marbore 2	CFJ	1	1	A	880 lb. t.	1.09	3.6	1.9	5.13	309	CM 170 & 175 Fouga Magister MS 760 Morane Saulnier-CT20 Avion Chile Beech B-73-Cessna T-37A Temco TT1 Cannon YT1 Ryan Q2
	Marbore 6	CFJ	1	1	A	1,060 lb. t.	1.05	3.8	1.9	4.8	308	Can replace Marbore 2
	Palas	CFJ	1	1	A	352 lb. t.	1.17	3.93	1.3	4.0	158	Midget Fouga Bretagne SO-30P SIPA S-200 & S-300
	Palouste 4		1	2	A	2.52 lb/sec.	260 lb/hr	3.80	1.8	4.0	200	Djinn SO 1221 helicopter ground starting Boom
	Turmo 3C(2)		2	3	A		.63	5.50	2.10	5.5	414	Sud Aviation SE 3200
	Turmo 3C3		2	2+1	A	1,500 eshp.	.61	5.50	2.15	5.9	414	Sud Aviation "Super Frelon" helicopter
	Turmo 3D(2)		2	3	A	1,335 eshp	.61	5.80	2.87	6.0	661	Breguet 941-942
	Turmo 3D(3)		2	1+2	A		.63	5.80	2.87	6.0	661	G.A.M. Dassault Spirale 3
	Turmo 5		3	2+2	A	2,000 eshp.	.55		2.87	6.0	1,103	Breguet 945
ITALY Fiat-SMA *Turin*	4700 005	CFG	1	1+1	A	350 ghp.	1.30	4.0	24.1	31.2	336	Free turbine moving stage centrifugal flow compressor
	4701 000	CFP	1	1+1	A	670 shp.	1.11	4.0	22.4	60.1	386	Free turbine moving the reduction gear
	4350 500	CFS	1	1+1	A	670 shp	1.11	4.0	22.4	40.8	344	Free turbine moving the reduction gear
	4350 001	CFS	1	1+1	A	700 shp.	0.90	4.0	22.4	52.3	440	Free turbine moving the reduction gear
	4004 000	CFJ	1	1	A	595 lb. t.	1.18	4.0	22.4	31.2	209	
	4004 001	CFJ	1	1	A	595 lb. t.	1.18	4.0	22.4	34.76	168	

Circle Number 217 on Reader Service Card

Circle Number 219 on Reader Service Card

← Circle Number 216 on Reader Service Card

Leading International Rotary-Wing Aircraft

Country, manufacturer and address	Model designation	Name	Total seats, incl crew	DIMENSIONS: Rotor diameter, ft.	DIMENSIONS: Max. length fuselage unfolded, ft.	DIMENSIONS: Max. height, ft.	WEIGHTS: Weight empty, lb	WEIGHTS: Normal gross weight, lb	POWERPLANT: Number/make, model	PERFORMANCE: Maximum speed, mph.	PERFORMANCE: Hovering ceiling in ground effect, ft.	PERFORMANCE: Max. still-air range, mi.	Remarks
CANADA													
Avian Aircraft Ltd *Georgetown, Ont*	2/180	Gyrophus	2	33 0		5 0	1 090	1 720	1 Lyc O-360-A	130		400	
CZECHOSLOVAKIA													
Omnipol Ltd. *Prague 5*	HC-2 HC-3	Heli Baby	2 3	23 8 38 0	34 3	8 2 12 8	838	1 280 3 968	1 130-hp piston engine 1 M 108H	81 100	3 940	65	Ourdied in export-sales organization for all Czech manufactured products.
FRANCE													
Sud-Aviation *Paris*	SE 3130 SE 3160 SO 1221 SA 3210	Alouette 2 Alouette 3 Djinn Super-Frelon	5 7 5 32	33 0 36 1 36 3 62 0	31 0 33 5 17 0 55 9	9 0 10 5 9 4 16 1	1 962 2 400 760 13 230	3 300 4 630 1 764 24 250	1 Tur Artouste 2C 1 Tur Artouste 3B 1 Tur Palouste 4 3 Tur Turmo 3C	191 183 91 170	6 560 5 360 5 300 10 900	372 483 140 806	Sud also builds the Sikorsky S-58 under license; bid with 2 Turbomeca Bastan 4 gas turbines as the powerplant
GERMANY (Federal Republic)													
Bolkow-Entwicklungen KG *Ottobrunn/Munich*	Bo-46 Bo-103		1	33 0 21 8				5 000 882	1 Agusta @ 82 hp	200 87		280	Lead-lag rotor system
Merckle Flugzeugwerke GmbH *Ulm/Donau*	SM 07		9	34 4	41 8	9 2	2 280	3 740	1 Tur Artouste 2C	126			
GREAT BRITAIN													
Westland Aircraft Ltd. *Yeovil*		Widgeon	5	40 2	40 8	13 0	4 322	5 500	1 Alv Leonides 521/2	110	6 000	300	Widgeon Whirlwind and Wessex are basically Sikorsky S-51 S-55 and S-58 built under license. Belvedere was originally the Bristol 192 Series 2. Scout was originally the Saunders-Roe P.531. Naval version is designated Wasp and differs only in detail.
		Whirlwind 1	8	53 0	41 8	13 3	5 000	7 800	1 P&WA R1340-40	110	4 700	264	
		Whirlwind 2	9	53 0	41 8	13 8	5 375	8 000	1 Alv Leonides Major 755	110	6 000	330	
		Whirlwind 3	8–10	53 0	41 8	13 3	4 700	8 000	1 RR Gnome H 1000	130	10 100	310	
		Wessex 1	14–16	56 0		14 8	7 500	12 500	1 Nap Gazelle N Ga 13	133	5 000	300	
		Wessex 2	14–18	56 0		14 3	11 022	19 000	2 RS Gnome H 1000	133	14 200	270	
		Belvedere	20–27	48 0		17 5	11 121	18 000	2 Nap Gnome N Ga 2	138	4 850	420	
		Scout	5–9	32 3		10 4	4 340	5 000	1 RS Nimbus 750	127	17 800	288	
		Skeeter 12	1	32 0		10 2	1 878	2 250	1 DH Cirpy Major 215	122	5 900	214	
ITALY													
Costruzioni Aeronautiche Giovanni Agusta S.p.A. *Cascina Costa (Gallarate)*	204 B		16	44 0	53 0	12 5	4 100	7 500	1 RS Gnome H 1000	138	13 000	175	Models 101G, A104 and AB102 are original Augusta designs. All others are based on Bell Helicopter Corp models and are produced under license
	101 G		32	58 0	67 0	16 0	12 600	24 000	2 RS Gnome H 1000	143	5 840	810	
	A104		2	26 9	30 0	7 7	840	1 410	1 M V A 120	103	1 800	205	
	AB102		8	43 0	58 7	10 6	3 950	6 000	1 P&WA R1340-S1H4	100	8 100	248	
	47G-2		3	35 1	41 2	9 2	1 560	2 450	1 Lyc VO-435-A1	130	10 850	238	
	47G-2A		3	37 1	43 2	9 3	1 649	2 850	1 Lyc VO-435-A1E	103	4 500	202	
	47G-3B		3	37 1	43 2	9 3	1 748	2 850	1 Lyc TVO-435-A1A	105	13 000	192	
	47G-3B1		3	37 1	43 2	9 3	1 773	2 850	1 Lyc TVO-435-B1A	108	10 800	273	
	47J		4–5	37 1	43 2	9 3	1 943	2 850	1 Lyc VO-435-A1E	106	4 830	248	
	47J-2		4–5	37 1	43 2	9 3	1 703	2 850	1 Lyc VO-540-B1B3	105	9 100	200	
	47J-3		4–5	37 1	43 2	9 3	1 786	2 850	1 Lyc VO-540-B1E3	95	6 900	233	
	47J-3B		4–5	37 1	43 2	9 3	1 803	2 850	1 Lyc TVO-435-B1A	105	10 800	210	
Fiat D v Aviazione *Turin*	T602		7	30 4	39 4	9 4	1 320	3 085	1 Fiat 4700 800	100			Cold jet rotor system
Aer Lualdi *Milan*	L59		2	35 1	40 0	9 8	1 700	2 684	1 Con 10-470-D	100	8 875		

ABBREVIATIONS:
Alv —Alvis
BS —Bristol Siddeley
Cou —Continental Motors
DH —De Havilland
Lyc —Lycoming
Nap —Napier
P&WA —Pratt & Whitney
Tur —Turbomeca

SUPERSCRIPTS
1—Calculated

Westla...
We...

Leading International Aircraft

Manufacturer	Model designation	Aircraft name	Primary mission	Max. No. of crew	Max. No. of passengers	Wingspan, ft.	Max. length, ft.	Max. height, ft.	Empty weight, lb.	Gross weight, lb.	Number, make & model	Max. speed, mph.
ARGENTINA												
DINFIA-F.M.A. Fabrica de Aviones *Cordoba*	I A 35	Huanquero	Various	3	8	64 3	45 9	13 4	7 700	13 700	2 I A 19R re.	225
	I A 45	Querandi	Transport	2	4	41 5	29 0	9 2	2 426	3 670	2 Lyc O-320 re.	
	I A 46	Ranquel	Utility	1	2	38 8	24 0	7 8	1 213	2 204	1 Lyc O-320 re.	
	F A I	Gaviani I	Transport	2	15	84 0	49 0	9 5		14 330	2 Tur Bastan 3A	
	F A 2	Gaviani 2	Transport	2	16	84 0					2 Tur Bastan 3A	
AUSTRALIA												
Commonwealth Aircraft Corporation Pty., Ltd *Port Melbourne, Vic*	CA-25	Winjeel	Trainer	3	6	38 8	28 0	9 9	3 280	4 985	1 P&W R985-AN2	187
	CA-27	Sabre Mk. 31	Fighter	1	0	37 1	37 5	14 7	11 000	20 500	1 R-R Avon R.A.26	700
	CA-28	Ceres	Agricultural	1	9	47 0	30 3	9 0	4 000	7 000	1 P&W Wasp 532HG	140
AUSTRIA												
Josef Oberlerchner Holzindustrie *Spittal/Drau*	JOB 1 5		Personal	2	1	38 2	20 2	8 5	1 270	5 050	1 Lyc O-320	135
Simmering-Graz-Pauker A.G *Vienna 7*	M-222	Flamingo	Personal	1	3	39 5	28 5	10 0	2 700	4 190	2 Lyc IO-360	200
BELGIUM												
Avions Fairey S.A. *Gosselies*	T98 Mk. 2	Tipsy Nipper	Personal	1	0	19 7	15 9	6 0	412	699	1 Stark 1 099A	107
BRAZIL												
Sociedade Construtora Aeronautica Neiva Ltda. *Botucatu, S.P.*	P-56-C	Paulistinha	Trainer	1	1	35 3	22 0	8 5	880	1 300	1 Con C-85-8F	128
	N-601	Regente	Personal	1	3	35 5	24 5	8 9	1 220	2 320	1 Lyc O-360-A1A	190
CANADA												
Avro Aircraft Div *Malton Ont*	CF 100 Mk 5		Interceptor	2	0	60 3	54 2	14 5	29 100	33 000	2 Orenda 11	600
Canadair Ltd. *Montreal P.Q.*	CL-41A	Tutor	Trainer	2	0	36 5	32 0	9 3	4 870	7 380	1 GE J85-CAN-40[1]	400
	CL-41R		Elec. trainer	2	6	36 5	42 2	9 3	5 690	8 000	1 GE J85-CAN-40[1]	485
	CL-44-6	Yukon	Transport	6	134	142 3	130 7	38 7	80 250	205 000	4 R-R Tyne 12	400
	CL-44D4	Forty Four	Cargo/pass	4	178	142 3	126 7	38 7	82 500	210 000	4 R-R Tyne 12	435
	CF-104G[1]		Strike/fighter	1	0	21 0	51 5	13 5	13 500	26 000	1 GE J79-OEL-7	M>2
The De Havilland Aircraft of Canada, Ltd *Downsview, Ont*	DHC-2	Beaver	Transport	1	7	48 0	30 3	9 0	3 060	5 100	1 P&W R985 Wasp Jr.	160
	DHC-3	Otter	Transport	2	11	58 0	41 8	12 6	4 631	8 000	1 P&W R1340-S2H2-G	150
	DHC-4	Caribou	Transport	2	32	95 0	72 0	31 8	17 485	28 500	1 P&W R2000-7M2	214
CZECHOSLOVAKIA												
Omnipol Foreign Trade Corp. *Prague 1*	Aero 145		Transport	1	4	40 9	25 5	7 5	3 110	3 527	5 Walter M-332	
	L-200A	Morava	Transport	1	4	38 4	25 8	7 3	2 865	4 960	1 ZJ M-337	
	L-40	Meta Sokol	Personal	1	3	32 9	24 9	8 3	1 170	2 062	1 ZJ M-332	
	L-29		Trainer	2	0						1 turbojet	
	Z-326	Trener Master	Trainer	2	0	34 8	25 8	8 0	1 404	1 984	1 Zlin M-6-3	
FRANCE												
Societe Anonyme des Ateliers et Avietion Louis Breguet *Paris 16*	1050	Alize	A/W	2	0	51 2	46 4	15 5	12 550	18 100	1 R-R Dart 21	255
	761	Provence	Transport	6	107	140 7	94 3	31 3	68 180	113 500	4 P&W R2800-CA18	272
	765	Sahara	Transport	4	128	140 7	94 9	31 3	68 343	119 000	4 P&W R2800-CB16	295
	1150	Atlantic	A/W	12	0	124 9	92 8	38 5		93 500	2 R-R Tyne R.Ty.20 Mk.21	380
	940	Integral	STOL research	0	0	57 4	76 3			18 500	4 Tur Turmo 2	230
	941		STOL trans.	2		76 0	71 0	29 0	25 860	45 000	4 Tur Turmo 3D	350
Generale Aeronautique Marcel Dassault *Vaucresson (S & O)*		Mirage 3C	Fighter	1	0	27 0	43 9	14 8	14 000	22 000	1 Snecma Atar 9B	M>2
		Mirage 3R	Recon/fighter	1	0	27 0	46 0	14 5			1 Snecma Atar 9C	M>2
		Mirage 3B	Trainer	2	0	27 0	41 8	14 8	11 540	17 460	1 Snecma Atar 9B	M>2
		Mirage 3E	Strike/fighter	1	0	27 0	41 8	14 8			1 Snecma Atar 9C	M>2
		Mirage 4V	VTOL fighter	1	0						1 Snecma TF 106 + 8 R-R R.B 108	
		Balzac 5	VTOL research	1	0	27 0	41 8	14 8			1 BS Orpheus + 8 R-R R.B108	
		Etendard 4M	Fighter	1	0	31 5	47 3	14 1		18 500	1 Snecma Atar 8	
		Mystere 29	Transport	5	0	44 3	31 5	10 1	10 250	20 060	2 P&W JT12A 8	
		Mirage 4	Bomber	3	0	38 3	77 0	18 5		66 000	2 Snecma Atar 9D	M>2
Avions Marcel-Dubois *Mission 16 & O*	H.D 34		Photo	7	0	148 7	77 5	28 7	26 300	42 000	5 Wr 902C92E2	260
Morane-Saulnier *Puteaux (Seine)*	M.S 733	Alcyon	Trainer	3	3	37 0	31 1	11 8	2 816	3 850	1 Potez 6 D02A	164
	M.S 760	Paris I	Business	1	3	33 3	32 0	8 5	4 100	7 050	2 Tur Marboré 2	405
	M.S 760B	Paris 2	Business	1	3	33 3	33 5	8 5	4 670	8 542	2 Tur Marboré 6C	432
	M.S 760B	Paris 2	Trainer	2	0	33 3	33 5	8 9	4 541	7 330	2 Tur Marboré 6C	432
	M.S 760C	Paris 3	Business	1	4	33 3	35 9	8 5	4 872	8 342	2 Tur Marboré 6C	411
	M.S 880	Rallye	Personal	1	2	31 5	20 8	5 9	990	1 720	1 Con O-200 A	121
	M.S 885	Super Rallye	Personal	1	2	31 5	22 8	8 5	1 100	1 874	1 Con O-300 A B C D	138
	M.S 880	Carrelance	Personal	1	3	31 5	22 8	8 5	1 190	2 205	1 Con O-360 A B C D	134

Superscript 1—Built under license

Manufacturer	Model designation	Aircraft name	Primary mission	Max. No. of crew	Max. No. of passengers	Wingspan, ft.	Max. length, ft.	Max. height, ft.	Empty weight, lb.	Gross weight, lb.	Number, make & model	Max. speed, mph.
FRANCE (Continued)												
Nord-Aviation *Paris*	2501	Noratlas	Transport	6	42	107 6	72 0	10 1	28 600	48 400	2 Saecma Hercules	275
	2502	Nomades	Transport	3	40	110 3	72 0	10 0	26 000	90 709	2 Snecma Hercules 758/759 +	
											2 Tur Marboré 2	
	3202		Trainer	2	0	43 0	29 3	10 2	1 813	2 465	1 Potez 4 D-32	161
	3400	Super Broussard	Observation	1	1	41 7	37 7	10 2	2 923	2 976	1 Potez 4 D-30	124
	M H. 260		Transport	2	26	71 9	57 7	20 5	8 735	15 076	2 Tur Bastan 9D	230
	M H. 261		Transport	2	26	71 9					2 Tur Bastan 9	
	C 160[2]	Transall[2]	Mil transport	4	80	131 3	103 5	36 0	90 657	108 025	2 R-R Tyne R. Ty 20	
Etablissements Henry Potez *Paris*	C M. 170	Magister	Trainer	2	0	37 0	33 0	9 0	4 268	6 078	2 Tur Marboré 2A	435
	C M. 175	Zephyr	Trainer	2	2	37 0	33 5	8 0	4 200	7 417	2 Tur Marboré 2B	403
	P. 840		Transport	8	24	63 0	51 3	17 6	10 990	18 740	4 Tur Astazou 2	335
Reims Aviation *Reims*	M H. 1521	Broussard	Utility	1	8	45 1	28 3	12 0	3 373	5 925	1 P&W R985	185
Sud-Aviation *Paris 16*	G1 30	Horizon	Personal	1	3	31 8	21 5	8 0	1 254	2 249	1 Lyc O-320	
	S E 210	Caravelle 3	Transport	3	80	112 5	105 0	29 5	60 000	101 413	2 R-R Avon 527	570
	S E 210	Caravelle 6	Transport	3	80	112 5	105 0	29 5	61 222	104 522	2 R. R Avon 531	524
	S E. 210	Caravelle 6R	Transport	3	80	112 5	105 0	29 5	63 206	110 231	2 R. R Avon 533R	534
	S.E. 210	Caravelle Super A	Transport	3	80	112 5	108 3	29 3	68 050	114 640	2 GE CJ805-23C	550
	S.E. 210	Caravelle Super B	Transport	3	80	112 5	108 3	29 5	66 425	114 640	2 P&W JT3D-1	523
		Caravelle[2]	Transport		100	77 0	170 0		104 720	220 000	4 BS Olympus 593/3	M=2 2
GREAT BRITAIN												
British Aircraft Corporation Ltd. *London SW 1*	BAC 111	Concorde[2]	Transport	3	100	77 0	170 0		104 720	220 000	4 BS Olympus 593/3	M=2 2
	TSR. 2	One Eleven	Transport		79	88 5	82 5	23 8	43 516	73 000	2 R-R Spey RB. 163-2	540
			Strike/recon.		0						2 BS Olympus	M>2
Bristol Aircraft Ltd. *Bristol*	175	Britannia 100	Transport	6	62	142 3	114 0	38 7	86 000	155 000	4 RS Proteus 705	370
	175	Britannia 200	Transport	6	115	142 3	124 3	37 5	90 000	155 000	4 RS Proteus 765	410
	175	Britannia 300	Transport	6	132	142 3	124 3	37 5	92 000	165 000	4 RS Proteus 766	410
	175	Britannia 310	Transport	6	133	142 3	124 3	37 5	93 100	165 000	4 RS Proteus 765	410
	175	Britannia 320	Transport	6	133	142 3	124 3	37 5	93 100	185 000	4 RS Proteus 750	410
	188		Research		0	75 1	71 0	13 3			2 DH Gyron Jr.	M>2
English Electric Aviation Ltd. *London*		Lightning F 1, 2, 3	AW fighter	1	0	34 8	50 0	19 4			2 R-R Avon	M>2
		Lightning T. 4, 5	Trainer	2	0	34 8	50 0	19 4			2 R-R Avon	M>2
		Canberra B. 6	Bomber	2	0	64 0	65 5	15 0	24 500	55 000	2 R-R Avon	
		Canberra P.R. 7	Photo. recon.	2	0	64 0	66 7	15 8	24 700	55 000	2 R-R Avon	M= 7
		Canberra B (I) 8	Bomber	2	0	64 0	65 5	15 8	25 900	55 250	2 R-R Avon	
		Canberra P. R. 9	Photo. recon.	2	0	64 0	66 7	15 6			2 R-R Avon	
Hunting Aircraft Ltd. *Luton, Beds*	P. 84/2	Jet Provost T. Mk. 3	Trainer	2	0	36 9	32 4	10 5		7 110	1 BS Viper 8	344
	P. 84/4	Jet Provost T. Mk. 4	Trainer	2	0	36 9	32 4	10 2		7 400	1 BS Viper 11	411
Vickers-Armstrongs (Aircraft) Ltd *Weybridge, Surrey*	700	Viscount	Transport	3	53	93 7	81 4	28 5	35 000	62 000	4 R-R Dart Mk. 509	328
	700D	Viscount	Transport	3	65	93 7	81 6	28 5	37 000	64 500	4 R-R Dart Mk 510	315
	800	Viscount	Transport	3	73	93 7	85 7	28 5	38 900	64 800	4 R-R Dart Mk 510	310
	810	Viscount	Transport	3	73	93 7	85 7	28 5	41 365	72 500	4 R-R Dart Mk 525	370
	950	Vanguard Mk 2	Transport	3	135	118 0	122 8	34 0	90 314	146 050	4 R-R Tyne Mk. 512	415
	1100	VC 10	Transport	5	135	146 2	158 8	39 5	138 000	310-000	4 R R Conway Mk 540	600
		Super VC 10	Transport	5	163	146 2	171 7	39 3	147 860	322 000	4 R R Conway Mk. 550	600
		Scimitar F. Mk. 1	Fighter	1	0	32 2	55 3	15 0			2 R-R Avon 200 series	M = 0
	674	Valiant B. Mk 1	Bomber	5	0	114 3	108 2	32 2	75 800	140 000	4 R-R Avon Mk 204	M= 91
British Executive & General Aviation Ltd. (Holding Co.) *Bembridge Aircraft Ltd. Rearsby, Leicester*	A 91	Terrier 2	Trainer	1	2	36 0	23 3	8 0	1 600	2 400	1 DH Gipsy Major 10	110
	A 109	Airedale 1963	Business	1	3	36 3	26 3	10 0	1 700	2 750	1 Lyc O-360 A1A	141
	A 110	Mark Eleven	Observation	3	0	36 3	33 7	7 3	1 804	3 750	1 R-R Con IO-470 D	
	D5-180		Utility	1	2	36 3	28 3	8 3	1 410	2 400	1 Lyc O-360 A2A	125
Beagle Aircraft Ltd. *Shoreham Sussex*	M 117		Personal	1	3	37 0	26 5	8 5	1 677	2 650	1 R-R Con O-300-F	147
	M 218		Business	1	3	37 0	28 4	8 5	2 250	3 300	2 R-R Con O-300-E	183
	B 206		Business	1	7	40 0	33 8	11 3	4 378	7 000	2 R-R Con GIO-470-A	225
Hawker Siddeley Group *London*												
Blackburn Aircraft Ltd. *Brough, Yorks*		Beverley C. Mk. 1	Mil. transport	4	87	162 0	99 4	36 4	83 100	146 000	4 BS Centaurus	238
	NA 39	Buccaneer S. Mk. 2	Strike	2	0	42 5	63 3	16 3			2 R-R Spey RB. 163-11	M=1 at s.l.
De Havilland Aircraft Co. Ltd. *Hatfield Herts*	D H 104	Dove 8	Business	2	8	57 0	39 3	13 3	5 670	8 950	2 DH Gipsy Queen 70 Mk. 3	060+
	D H 106	Comet 4	Transport	4	81	114 8	111 6	29 6	73 000	162 000	4 R R Avon 29	531
	D H 106	Comet 4B	Transport	4	102	108 0	118 0	29 5	75 100	158 000	4 R R Avon 29	542
	D H 106	Comet 4C	Transport	4	102	114 8	118 0	29 5	75 000	162 000	4 R R Avon 29	531
	D H 110	Sea Vixen	AW fighter	2	0	50 0	53 5	11 0			2 R-R Avon	M>1
	D H 114	Heron	Transport	6	17	71 6	48 5	15 6	8 484	13 500	4 DH Gipsy Queen 30 Mk. 2	191
	D H 121	Trident 1E	Transport	4	109	95 0	114 8	27 0	69 949	128 000	3 R R Spey RB 163-2W	001
	D H 121	Trident 1F	Transport	4	117	95 0	123 5	27 0	78 131	128 000	3 R R Spey RR 163-2W	001
	D H 121	Trident 1C	Transport	5	101	89 8	114 8	27 0	67 551	115 000	3 R R Spey RB 163-1	903
	D H 125		Business	2	10	47 6	47 4	18 0	9 010	10 000	2 BS Viper 520	000

Superscript 2 Joint project

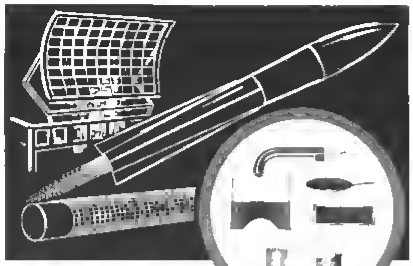
Leading International Aircraft

Manufacturer	Model designation	Aircraft name	Primary mission	GENERAL: Max. No. of crew	GENERAL: Max. No. of passengers	DIMENSIONS: Overall wingspan ft.	DIMENSIONS: Overall length, ft.	DIMENSIONS: Max. height, ft.	WEIGHTS: Empty weight, lb.	WEIGHTS: Gross weight, lb.	POWERPLANTS: Powerplants	POWERPLANTS: Max. speed, mph
Folland Aircraft, Ltd *Southampton, Hampshire*	FO 141	Gnat Mk 1	Fighter	1	0	22 2	20 7	8 8	4 700	8 750	1 B.S. Orpheus 701	M 0.8
	FO 144	Gnat Trainer	Trainer	2	0	24 0	31 0	10 5	6 500	7 920	1 B.S. Orpheus 101	M 0.5
Hawker Aircraft, Ltd *Kingston-on-Thames, Surrey*	P 1067	Hunter G.A. 11	Naval ground attack	1	0	33 7	45 8	13 2	13,100	25 500	1 R-R Avon/RA.211 Mk 122	M 0.1
	P 1083	Hunter F. 6	Interceptor	1	0	33 7	45 6	13 2	13,500	25 000	1 R R Avon Mk 203	M 0.5
	P 1088	Hunter F.G.A. 9	Ground attack	1	0	33 7	45 6	13 2	13,750	24 100	1 R R Avon Mk 207	M 0.9
	P 1094	Hunter T. 8	Recon. Fighter	1	0	33 7	48 2	13 2	13,800	21 100	1 R R Avon Mk 207	M 0.9
	P 1101	Hunter T. 7	Op. Trainer	2	0	33 7	48 8	13 2	11 240	21 200	1 R R Tyne Mk. 122	M 0.8
	P 1101	Hunter T. 66	G. Trainer	2	0	33 7	48 8	13 2	11,850	21 000	1 R R Avon Mk. 207	M 0.9
	P 1127		Strike Fighter/ VTOL	1	0	24 3	41 2	10 7			1 B.S. Pegasus 3	
	P 1154		Strike/Air Superiority Fighter	2	0						1 B.S. BS 100	Super-sonic
A. V. Roe & Co., Ltd. *Manchester*	698	Avro Vulcan B. Mk 2	Bomber	5	0	111	97 1	27 2			4 R.S. Olympus 201	
	805	Avro Shackleton Mk 3	Anti-Sub.	10	0	119 5	87 3	33 3		100 000	4 R-R Crifton 5A	300
	748 Series 1		Transport	2	48	98 9	67 0	24 8	22-041	38 600	2 R R Dart R. Da. 6 Mk. 514	288
	748 Series 2		Transport	2	52	98 5	67 0	24 8	21 500	42 000	2 R R Dart R. Da. 7 Mk. 531	312
	748 MF		Transport	2	48	98 0	77 0	29 1	27 272	47 [1]	2 R R Dart R. Da. 12	
Whitworth Gloster Aircraft, Ltd *Warwickshire*	AW 650	Argosy Series 100	Freighter	3	89	115	86 8	27 0	47-421	88 000	4 R R Dart	286
	AW 650	Argosy Series 200	Freighter	3	84	115	86 8	29 3	49 000	89 000	4 R-R Dart 526	300
	AW 660	Argosy	Freighter	4	77	115	89 0	27 0	58,000	97 000	4 R R Dart R. Da. 8	326
	AW 670	Argosy Air Plus	Freighter (can/ passenger)	5	72	115	88 0	27 6	57 500	88 000	4 R R Dart	305
	AW 671	Argosy Airbus	High-density Passenger	3	114	115	88 0	27 0	58 000	88 000		
	FGA. Mk. 9	Sea Hawk	Fighter Bomber	1	0	39 0	39 7	8 7	13 200	16 200		524
	F(A.W.) 7	Javelin	AW Fighter	2	0	52 0	56 5	16 0			2 R S. Sapphire 7R	
	F(A.W.) 8	Javelin	AW Fighter	2	0	52 0	56 5	16 0			2 R S. Sapphi re 7R	
	F(A.W.) 9	Javelin	AW Fighter	2	0	52 0	56 7	16 0			2 R S Sapphire 7R	
Handley Page, Ltd *Cricklewood, London*	H.P. 80	Victor B. Mk 1	Bomber	0	0	110	114 0	28 1			4 R S. Sapphire	
	H.P. 80	Victor B. Mk 2	Bomber	5	0	120	111 0	28 1			4 R R Conway	
	H.P.R. 7	Dart Herald Series 100	Transport	0	44	94 3	71 0	24 0	23 600	46 000	2 R-R Dart	298
	H.P.R. 7	Dart Herald Series 200	Transport	2	60	81 3	75 4	21 0		48 000	3 R-R Dart Mk. 527	
	H.P. 113		Transport	2	12	71 3	71 5	17 0		36 500	2 R.S. Orpheus	539
	H.P. 115		Research	1	0	20 0	50 8	12 3			1 R.S. Viper ASV.9	
Scottish Aviation, Ltd *Prestwick Airport Ayrshire*	CC Mk 1	Prestwick Pioneer	Transport	1	4	46 3	34 3	16 1	4 200	7 400	1 Al. Lonsdale 330 7	115
	CC Mk 1 32	Twin Pioneer	STOL Transport	2	10	76 5	43 3	12 3	10 158	11 900	2 Al. Lonsdale 541 8S	173
Short Brothers & Harland, Ltd. *Queens Island, Belfast*	SC 5/10	Belfast	Strategic Trans.	4	242	150	146 5	47 0	121 100	230 500	4 R-R Tyne TY10	386
	SC 8/20	Belfast	Tactical Trans.	4	147	150	130 5	47 0	105 000	220 500	4 R-R Tyne TY22	
	SC 5/31	Belfast	Civil Transport	4	141	150	146 5	47 0	111 000	300 000	4 R-R Tyne TY51	400
	SC 7 1	Skyvan 1	Freight & Pass.	2	15	84 1	38 8	13 8	6 000	6 500	2 Lim. GTS 10-520	196
	SC 7/2	Skyvan 2	Freight & Pass.	2	15	81 1	38 0	17 0	6 200	11 500	2 Tur. Astazou 2	201
	SB 5		Research	1	0	30 5	45 8	10 0			1 R.S. Orpheus	
	SI 1		VTOL	1	0	23 8	24 1	16 5			4 R-R RB108	
INDIA												
Hindustan Aircraft Factory *Bangalore*	HF 24		Fighter								2 Orpheus 12	M 2
	AVRO 748 [1]		Transport	3	44	95 0	67 0	24 0	22 914	38 000	2 R R Dart 514	281
ITALY												
Aeronautica Macchi *Corso Vittorio Emanuele 31 Milan*	Lockheed 50 [2]		Utility Transport	1	8	99 0	28 1	10 0	2 185	3 531	1 Lim. T-53-C-9 B	169
	MB 326		Trainer	1	1	32 0	34 4	11 3	5 027	7 430	1 R.R Viper 11	506
Aviamilano Costruzioni Aeronautiche *Milan*	F.14	Nibbio	Tourist	1	3	31 2	25 1	8 1	1 551	2 205	1 Lyc O-360 A2A	205
	P.19	Scricciolo	Trainer	1	1	33 8	24 1	6 7	991	1 440	1 Con I 90-12F	130
Fiat-Divisione Aviazione *Corso G. Agnelli 200, Turin*	G. 91		Fighter	1	0	28 1	31 2	13 1	6 000	11 350	1 B.S. Orpheus II Ib 80-02	711
	G. 91R/1		Recon Fighter	1	0	28 1	34 2	13 0	6 700	11 510	1 B.S. Orpheus B Ib 80-02	M 1
	G. 91R/3		Recon Fighter	1	0	28 1	33 8	13 1	6 353	11 905	1 B.S. Orpheus 803 D II	M 1
	G. 91R/4		Recon Fighter	1	0	28 1	33 8	13 1	6 415	11 755	1 B.S. Orpheus B Ib 80-02	M 1
	G. 91T		Trainer	2	0	28 2	34 6	14 5	7 210	11 905	1 B.S. Orpheus B Ib 80-02	M 1
	G. 91T/3		Trainer	2	0	28 2	34 6	14 5	7 405	11 905	1 B.S. Orpheus 803 D II	M 1
Piaggio & C. Societa per Azioni *Via Lungo Corso 6*	P. 166B	Portofino	Bus. Exec	2	6	41 8	39 0	16 4	5 172	8 378	2 Lyc IGSO-540-A1C	240
	PD-808 [2]	Ventura	Bus. Exec	2	6	46 7	41 6	14 7	8 338	15 000	2 P.W. Viper 525	516
PROCAER *1 bis Ward 4 Sforza 65 Milan*	F. 150	Pacific	Personal	1	3	32 9	21 6	5 0	1 510	2 420	1 Lyc O-360 A1A	185
	F. 400	Cobra	Personal	1	1	28 5	26 5	6 0	2 400	3 750	1 Tin Machrete 2F	352
SIAI *Sesto Calende*	F.S. 13	Rivolta	Amphibian Tourist	1	3	34 1	21 1	10 0	2 225	3 270	1 Con IO-470-A	180

[1] Built under license [2] Joint project

Manufacturer	Model designation	Aircraft name	Primary mission	GENERAL: Max. No. of crew	GENERAL: Max. No. of passengers	[illegible]: Overall Wingspan, ft.	[illegible]: Overall length, ft.	[illegible]: Max. height, ft.	[illegible]: Empty Weight, lb.	[illegible]: Gross weight, lb.	POWERPLANT: Number, make & model	POWERPLANT: Max. speed, mph
JAPAN												
Fuji Heavy Industries, Ltd. *Marunouchi Chiyoda Ku Tokyo*	T1A	T1F2	Trainer	2	0	34 4	30 8	13 2	5 335	10 670	1 Orpheus Mk 3/6	580
	LM1	Nikke	Trainer	1	4	32 7	26 0	9 4	2 104	3 527	1 Con O-470-13A	185
	KM	Super Nikko	Trainer	1	4	32 7	26 0	9 4	2 400	3.850	1 Lyc GSO 480-B1A6	228
Mitsubishi Industries Reorganized Ltd. Aircraft Dept. *Chiyoda-Ku Tokyo*	F-86F [1]	Sabre	Fighter-Bomber	1	0	39 1	37 5	14 8	11 010	20 245	1 GE J47-GE-27	680
	F104J [1]	Starfighter	Fighter	1	0	21 6	54 8	13 5		24 630	1 GE 479-GE-7	M 2
Nihon Aeroplane Mfg. Co., Ltd. *Minami-Sakunacho Shiba Minato-Ku Tokyo*	YS-11		Pass. Trans.	2	60	105	86 2	30	30 784	56 265	2 R R Dart R. Da 10 1 Mk 542	
NETHERLANDS												
Royal Netherlands Aircraft Factories (Fokker) *Schiphol-Zuid Amsterdam*	F27	Troopship	Military Trans.	2	45	95 1	77 1	27 8	23 000	38 000	2 R R Dart R. Da 6 Mk. 511	260
	F-27-100	Friendship	Transport	2	48	95 1	77 1	27 8	22 518	37 500	2 R R Dart R. Da. 6 Mk. 511	260
	F27 200	Friendship	Transport	2	48	95 1	77 1	27 8	22 965	38 000	2 R R Dart R Da. 7 Mk. 528 7E	280
	F-27-300	Fre ghtship	Pass./Cargo	2	48	95 1	77 1	27 8	21 830	37 500	2 R R Dart R Da 6 Mk. 511	260
	F27 100	Freighship	Fass. cargo	2	48	95 1	77 1	27 8	22 976	38 000	2 R R Dart R Da 7 Mk. 528-7E	280
POLAND												
Polish Aviation Works *Warsaw*	MD 12		Pass. Cargo	2	20	78 0	52 0	13 0	11 000	19 000	4 Nakowin WN-3	190
	MD 12F		Air Photo	2		78 0	52 0	10 6	12 100	15 430	4 Nak owin WN-3	190
	PZL 101	Gawron	Agricultural	1	0	44 5	29 4	9 0	2 200	3 660	A4-14R	103
	PZL 101A	Gawron	Air Ambulance	1	4	44 5	29 4	9 2	2 150	3 520	A4-14R	106
	PZL-102	Kos	Training	1	1	28 0	23 0	6 2	930	1 700	1 Con C90-12F	123
	PZL-104	Wilga	Multi-purpose	1	3	39 4	25 5	8 6	1 540	2 540	1 Vaklevcev WN-6RB2	118
SPAIN												
Aeronautica Industrial S.A. *Plaza de las Cortes 8 Madrid 14*	AISA I 115		Primary Trainer	2		31 3	21 1	8 8	1 340	1 980	1 Ennasa Tigre G-4 R	
	AISA I 11B		Tourist/ Training	1	1	30 6	21 5	8 3	926	1 474	1 Con C-90 12F	
Construcciones Aeronauticas, S.A *Calle del Rey Francisco, 4, Madrid 8*	C-207	Azor	Transport	4	40	31 2	28 4	25 4	23 300	36 375	1 Bristol Hercules 730	283
	C-101	Bucker	Trainer	2		24 2	22 1	7 3	1 000	1 580	1 Ensa ssi Tigr G-4 A	122
	C 127A [1]	Dornier	Liaison	1	4	34 1	31 4	11 4	2 230	3 500	1 Lyc GH-480 B1 A6	155
La Hispano Aviacion S.A. *Ave. Jose Antonia, 7, Madrid*	HA 100-E1	Turan	Adv. Trainer	2		31 1	29 4	9 8	4 150	5 900	1 Ennasa Beta B-4	275
	HA 200-B1	Saeta	Adv. Trainer	2		34 2	29 1	10 7	3 606	6 095	2 Turbomeca Marbore 11 A	435
SWEDEN												
Svenska Aeroplan Aktiebolagel *Linkoping*	Saab 29F	Tunnan	Fighter/ Bomber	1	0	36 0	33 5	12 3	10 200	17 600	1 Flygmotor RM2	690
	Saab 32A	Lansen	AW Attack	2	0	42 0	48 0	15 7	18 000	28 000	1 Flygmotor RM5	710
	Saab 32B	Lansen	AW Interceptor	2	0	42 6	47 5	15 5	17 600	28 000	1 Flygmotor RM6	710
	Saab 32C	Lansen	AW Photo/ Recon	2	0	42 6	48 0	15 7	18 000	27 600	1 Flygmotor RM 5	700
	Saab 35 A, B	Draken	AW Interceptor	1	0	30 8	51 5	12 7		20 000	1 Flygmotor RM 6B	M 1.6
	Saab 35C	Draken	Trainer	2	0	30 8	49 4	12 8		20 000	1 Flygmotor RM6B	M 1.8
	Saab 35D F	Draken	AW Interceptor	1	0	30 8	51 0	12 7			1 Flygmotor RM6C	M 2+
	Saab 35E	Draken	Photo Recon	1	0	30 8	51 9	12 7			1 Flygmotor RM6C	M 2+
	Saab 37	Vigeen	Version on	1	0						1 Flygmotor RM 8	M 2+
	Saab 91D	Safir	Train er/ Personal	2	3	34 4	28 3	7 2	1 960	2 900	1 Lyc O-360 A1A	170
	Saab 105		Trainer/ Personal/Attack	2	3	31 2	34 4	8 0	5 100	8.160	2 Turbomeca Artouste	000
SWITZERLAND												
Pilatus Flugzeugwerke A. G. *Stans at Foerrus*	P-3		Trainer	2	0	31 1	25 7	10 0	2 447	3.120	1 Lyc GO-435-C2A	192
	PC-6	Porter	Multi	1	7	49 0	31 4	10 5	2 400	4 320	1 Lyc GSO-480-B1A6	174
	PC-6/350	Porter	Multi	1	7	49 0	33 1	10 5	2 430	4 320	1 Lyc IGO-540 A1A	174
	PC-6/A	Turbo-Porter	Multi	1	7	49 0	35 0	10 5	2 305	4 320	1 Turbomeca Astazou 2	174
WEST GERMANY												
Bolkow-Entwicklungen K.G. *Ottobrunn bei Munchen*	BH 207		Personal	1	3	35 5	27 2	7 3	1 565	2.645	1 Lyc O-360 A1A	
	BH 208		Personal	1	1	24 3	18 1	6 5	750	1 270	1 Con O-200	
Dornier Werke G.m.b.H. *Friedrichshafen*	DH 27 [1]	Bregaet Albatic	Multi	2	4	39 3	31 4	8 8	3 420	1 040	1 Lyc-GO-480-B1A6	140
	DH 28		Multi	2	4	40 4	23 5	10 3	3 750	5.480	2 Lyc T-09 12F	174
	1150 [2]		ASW	12	0	124 0	90 0	30 0		86 000	2 R R Tyne R. Ty 20	
Ernst Heinkel Flugzeughau G.m.b.H *Sport am Alsyn*	CM-191A, B		Training/ Lesson	1	3	30 4	32 0	10 5	5 271	9.900	2 Turbomeca Marbore 4	441
Hamburger Flugzeughau G.m.b.H. *Hamburg-Finkenwerder*	RFB-320	Hansa	Business Short haul airliner	2	12	45 0	54 5	15 7	8 860	18.930	2 GE CJ610-4	510
Weser Flugzeugbau G.m.b.H. *Bremen*	C 160 [2]	Transall	Transport	4	80	131 2	103 6	36 0	80.697	108.025	2 R-R Tyne R Ty 20	

[1] Built under license [2] Joint project



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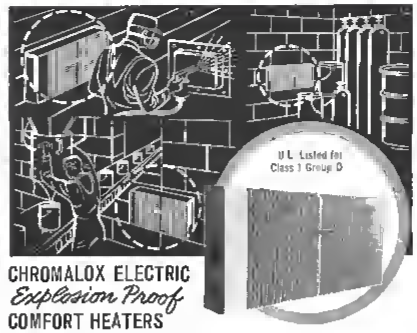

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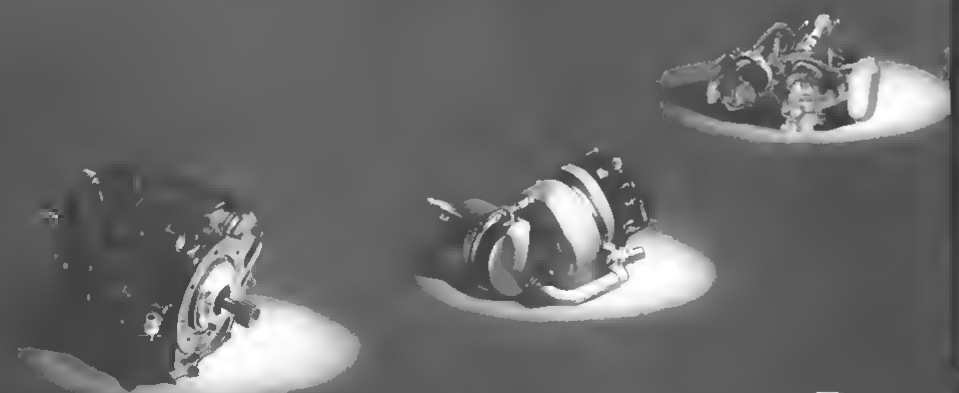
How does Sundstrand support our nation's defense effort?



Over the past 17 years, Sundstrand has gained recognition as the leading supplier of constant speed drives for airborne a-c electrical systems. Most military aircraft — bombers, fighters, interceptors, transports, tankers, reconnaissance — have been outfitted with Sundstrand Constant Speed Drives. Sundstrand has designed, manufactured, and delivered over 35,000 drive units and is credited with many state-of-the-art advancements. Over 20-million drive-flight-hours have been accumulated on Sundstrand drives on military aircraft. The new geared differential drive design is typical of Sundstrand's continual progress in constant speed drives to meet the more stringent requirements of advanced aircraft electrical systems.

Though dual-purpose starters with cartridge and pneumatic start capability are a rather recent requirement on some military aircraft, Sundstrand has already delivered more than 2600 cartridge/pneumatic starter units in support of the B-52, C-135B, F-100, and F4C aircraft programs. Sundstrand is also well along in the development of a lightweight cartridge/pneumatic starter unit for smaller classes of turbojet and turboprop engines.

Sundstrand has equally strong capabilities in secondary power system management. Technical depth, specialized procurement programming, facilities for total system testing, and long experience in design coordination with airframe builders, associated suppliers, and defense procurement groups enable Sundstrand to develop complete systems—from concept to final acceptance.

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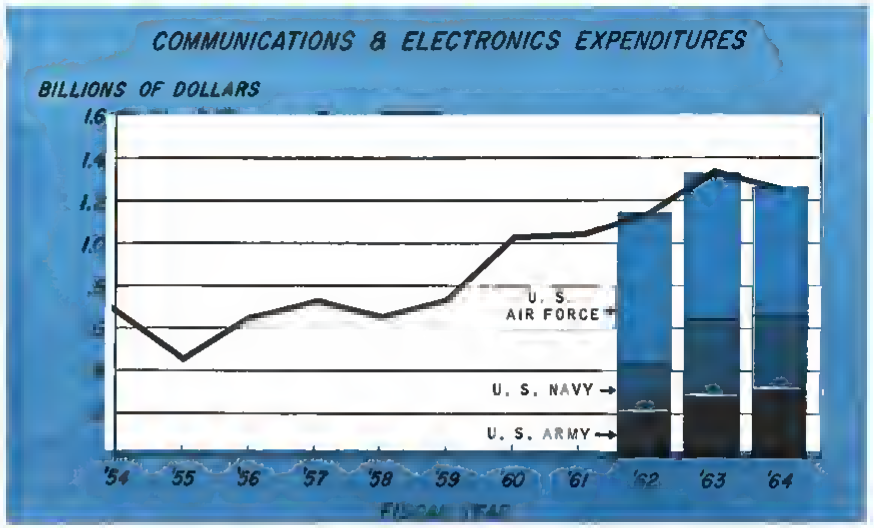
Avionics

Syncom Communications satellite, built by Hughes Aircraft Co. for NASA, undergoes final checkout by Hughes technicians at Cape Canaveral prior to first launch.



Defense Plan Lists Avionic Guidelines

By Philip J. Klass

Washington—Avionics manufacturers can look forward to new technological challenges stemming from Defense Department's increased emphasis on intercontinental ballistic missile defense and detection of missile-launching submarines.

At another extreme of the performance scale, progress in miniaturization and reliability gained in missile and spacecraft development may find new utilization in providing communications and navigation equipment for Army aviation's projected expansion.

Important guidelines to avionic areas destined to receive increased emphasis were spelled out by Defense Secretary Robert McNamara in his comprehensive statement on Administration defense strategy presented to the House Armed Services Committee.

While many of these philosophies previously have been stated piecemeal by President Kennedy, Secretary McNamara and other Defense Department officials, the broad outline of the Administration's defense philosophy had not previously been compiled in as comprehensive a blueprint for future action.

Of particular interest to avionics manufacturers are the following areas which are destined to receive increased emphasis in Fiscal 1964 and, if the Kennedy Administration is returned for a second term, for much of the current decade:

• **ICBM defense** is "the most urgent problem confronting us in the Continental Air and Missile Defense Forces Program," according to McNamara. "We believe it is premature at this time to commit ourselves to the production of any system. Instead, we propose to proceed with the greatest urgency in the development of the Nike-X system, retaining the option to move ahead with actual production and deployment of such a system, if the capabilities of the system and circumstances should warrant such a decision at some later time. I believe that the matter of anti-missile defense is so important that we must make every effort to develop an effective decision. Accordingly, over $450 million is included in the 1964 budget to initiate Nike-X development and continue the Nike-Zeus test program and related work under Project Defender," McNamara said.

• **Defense against submarine-launched** missiles is second only in importance to defense against ICBM attack," McNamara said. This involves three different types of capabilities (1) detection and tracking of enemy submarines, (2) destruction of these submarines before they have an opportunity to launch their missiles and (3) detection tracking and destruction of missiles once they have been launched. The funds requested for 1964 include "substantial improvement and augmentation of our existing submarine detection and tracking systems," McNamara said, with similar provisions for Navy's anti-submarine warfare capability. The 1964 program provides 'for enhancing our detection and tracking capability against submarine launched missiles," the Defense Secretary added.

• **Command and control systems** to assure that Strategic Retaliatory Forces be kept continuously under the control of the constituted authorities, from the President on down to the commanders of the forces before, during and after a nuclear attack, is a vital objective of the Kennedy Administration. The Strategic Air Command Control System, 465 L, currently being instilled, is expected to be adequate for peacetime and the pre-strike phase of a nuclear war.

But because the system is only partially hardened, "we cannot count on it functioning after an initial nuclear attack," McNamara said. Therefore, alternative systems must be provided for the post-attack phase," McNamara

noted that airborne elements of a Post Attack Command and Control System (PACCS), consisting of specially equipped KC-135 command post aircraft and B-47s equipped to serve as communication relay stations, are going into service. But he added that their airborne endurance and capabilities are limited. For this reason, Defense Department is proposing a deep underground support center which would have long endurance in a post-attack environment, with adequate space for communication and computer equipment and personnel. The proposed deep underground support center would complement the airborne command posts rather than be a substitute for them.

● **Army Aviation growth** is part of the Administration's policy of increasing the capability of the Defense Department to cope with limited non-nuclear war situations. The Fiscal 1964 budget request seeks $522 million for procurement of 1,600 Army aircraft, approximately three times the number purchased in 1962 and 1963. The largest procurement is expected to be for UH-1B/D Iroquois helicopters, with lesser numbers of smaller helicopters, and fixed-wing surveillance and transport aircraft.

While these Army aircraft individually do not offer a large market for airborne avionics equipment, collectively they present an attractive market and a challenge to the industry's technical ingenuity.

To operate successfully in a limited-war environment, such aircraft must be equipped with two-way radio communications with a navigation system which is sufficiently accurate to enable the crew to locate small targets, and in some cases with defensive armament capable of offering moderate protection against small arms fire.

Army Aviation needs night reconnaissance systems, capable of permitting its flight crews to locate targets of opportunity, and bombing systems for delivery of small non-nuclear weapons.

A decade ago when the Korean War focused attention on this type of military requirement, the state of the avionics art precluded any hope of providing so many functions in a size and weight needed for such small aircraft. Today, with advances achieved in microminiaturization and new developments in microcircuitry, it appears entirely possible to provide Army Aviation with the capability it needs in the size and weight it can tolerate.

But the challenge to avionics designers goes beyond size and weight. Such avionic subsystems must be designed and built to operate for extended periods with little if any maintenance. Skills and equipment available for avionics maintenance in a limited war situation are likely to be vastly more primitive than those available at Strategic Air Command and Air Defense Command bases within the United States.

Interestingly, the same design and manufacturing techniques which industry has been forced to develop to meet the demanding requirements of satellites and spacecraft, where size, weight, power consumption and reliability also are vital parameters, should be directly applicable to the needs of Army Aviation.

The reduction in funds requested for the Strategic Retaliatory Forces this year, $7.3 billion compared to $8.5 billion in Fiscal 1963 and $9.1 billion the previous year, reflects the present intention of the Pentagon to launch the development of new strategic weapon systems only if and when they appear to offer a significant gain over the present Minuteman and Polaris or improved versions of these missiles already under development.

The Pentagon plans to fund programs that could improve the capabilities of these basic weapons, in terms of their performance reliability and ability to penetrate enemy ICBM defenses. But the intention is to extract the maximum capability from these existing weapons rather than to launch major new programs.

In the field of command and control systems, a similar attitude prevails. Air Force currently has or is developing command and control systems for all of its major commands and functions. The only new one on the horizon is a system for the Strike Command (STRICOM).

Generally the emphasis in command and control systems will be on making them more responsive to the operational needs of the commanders they must serve and reducing their vulnerability to being knocked out in a surprise attack. While digital computers remain in vogue for use in command and control systems, there will be increased emphasis on communications rather than on data processing.

The budget category of "Electronics & Communications," representing items not funded directly as part of a weapon system and broadly encompassing the area of command and control is increased slightly from last year.

ELECTRONICALLY SCANNED phase-array radar, such as the Bendix ESAR here, will receive increased DOD emphasis because it is more easily hardened than conventional radar. The entire facility can be buried underground except for one flat face, and that can be protected by plastic covers to withstand all but a near hit. Sylvania is developing phased array radar for the Nike X anti-ICBM system and Sperry also is active in the field.

NEW BALLISTIC MISSILE EARLY WARNING SYSTEM (BMEWS) site at Fylingdales, England, has three tracking and surveillance rather than one installed at earlier sites. British station will become operational this summer.

With new funds requested, Defense Department will have an obligational authority of $1,526 million, compared to a figure of $1,334 million for 1963.

Army's share of this total, $406 million is roughly 28% above the previous year.

Largest item in this figure is $59 million for STARCOM—Army's Strategic Communications System—intended to provide rapid communications required by Army forces deployed around the world and by Strike Command should its forces be deployed.

Navy's share of the total is $550 million, an increase of 44% over Fiscal 1963. Air Force's share is $558 million, highest of the three services but 11% below the previous year.

If the Administration plans to be tight-fisted in launching major new weapon system programs it proposes a more liberal attitude toward research, exploratory development and advanced development which can improve the performance of existing weapons or unlock the door to more advanced weapons with significantly better capabilities.

Pentagon Philosophy

The philosophy of the Pentagon is to develop the techniques required to cope with a wide spectrum of military possibilities in the hope that as new threats develop the technology required for new weapons will be available, permitting rapid development and production of the needed hardware.

In the area of basic and applied research, the Defense Department is seeking $362 million for Fiscal 1964, an increase of 10% over the previous year.

Another $1,172 million has been requested for exploratory development. Air Force is seeking $330 million of this total, with almost one-third to be devoted to space projects. Other areas of interest to avionics manufacturers include projects planned in command and control, communications data processing, reconnaissance, electromagnetic warfare and advanced weapons.

Navy's Share

Navy's share of the exploratory development total is $368 million with about one-third of this total planned for anti-submarine warfare efforts. Army is seeking $217 million, while the Advanced Research Projects Agency seeks $256 million of which half would go for Project Defender—ICBM defense.

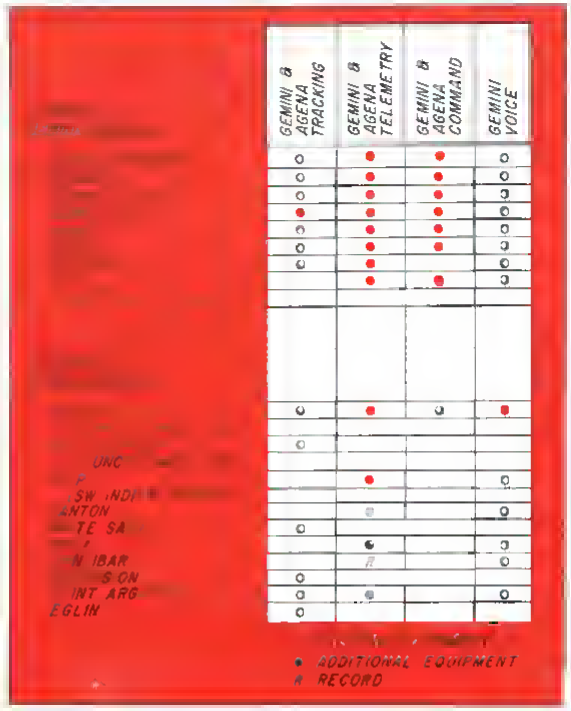
The areas of pressing military need set forth by Defense Secretary McNamara pinpoint the fields of avionic technological activity which are most likely to find support by the Pentagon and the military services.

● **Improved radar techniques** which make it possible to obtain more information on the characteristics of the target, to detect it at greater range and to track it more accurately. Desirability of having a hardened radar which can withstand all but a direct hit is likely to put increased emphasis on electronic scan type radars, such as the Bendix ESAR and the Sylvania ZMAR, which also have the advantage of being able to track a number of targets simultaneously. Improved radar technology is needed for space surveillance as well.

● **Higher-speed computers** for more rapid data processing of target data from ICBM defense radars, for command and control system functions and for intelligence data retrieval. One of the more promising new technologies is the optical computer using glass fiber lasers, which may permit a 10:1 or 100:1 increase in computation speeds. Rome Air Development Center currently is sponsoring exploratory development programs in such optical computers with American Optical Co., Radio Corp. of America and Stanford Research Institute.

● **Optical maser** (laser) continues to excite the imagination because of the diverse capabilities which it offers. There is continuing interest in the possibility of using the laser's highly concentrated energy as a kill mechanism against ICBMs and space vehicles, although Defense Department officials believe such a weapon is many years off if it does prove feasible. Discovery of the semiconductor laser during the past year, with conversion efficiencies vastly higher than previously available ruby and gaseous lasers, has added to enthusiasm over the laser's future. More recently, Sperry Rand scientists demonstrated an entirely new application when they constructed a ring of lasers which function as a rate gyroscope (AW Feb. 11, p. 93). NASA sees the laser as a great hope for communications over interplanetary distances.

● **Microcircuitry**, whose size, weight and power advantages are obviously important for missile and spacecraft applications, may have an equally important role to play in surface-based equipment which must be rapidly deployed around the globe via air transport, and for Army Aviation's small aircraft.



EXPANDED CAPABILITY planned for NASA's manned space flight network to accommodate needs of Gemini and orbital Apollo missions is shown above. New station at Carnarvon, Australia, is needed to handle variable inclination orbits planned.

NASA to Expand Tracking Network For Gemini and Apollo Missions

Washington—National Aeronautics and Space Administration has requested $349 million in Fiscal 1964 for expansion and improvement of its world-wide tracking and data acquisition network, roughly twice the funds authorized this year.

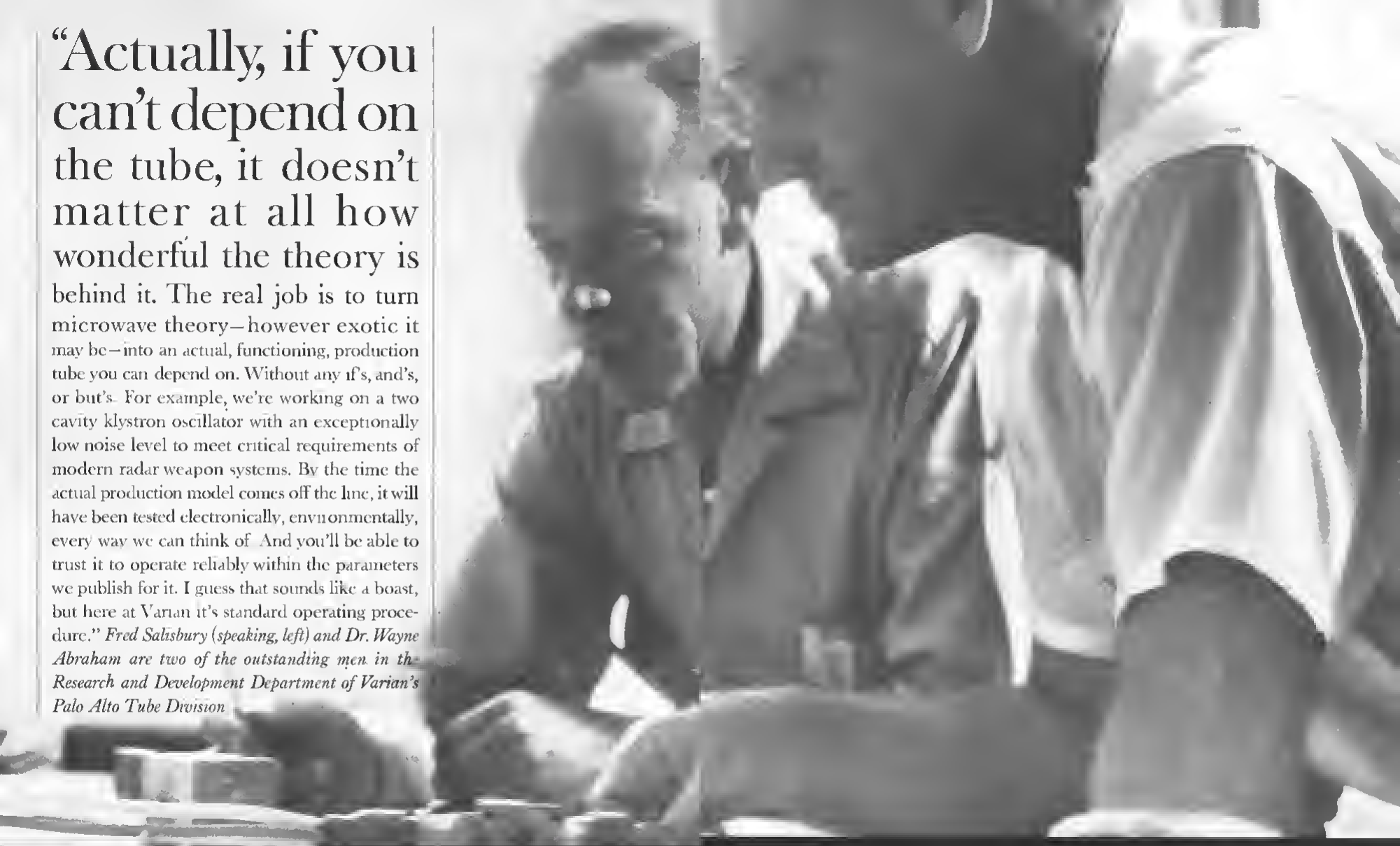
The expanded capability is intended to handle Gemini and early Apollo missions and growing numbers of scientific spacecraft.

To support Gemini, the orbital Apollo using Saturn 1 and Saturn B boosters, and the lunar Apollo using the Saturn 5, NASA is seeking funds for the following additions to the existing 17-station network used for Project Mercury:

- **New ground station** at Carnarvon, Northwest Australia, located at the antinodal point in the Gemini trajectory, is needed to handle the variable orbital inclinations planned for this program. Facility will be equipped with an AN/FPQ-6 radar, telemetry, voice and command capabilities.
- **Three instrumented ships,** outfitted to provide telemetry coverage of Apollo during critical portions of the mission, are expected to be contracted for during coming year.
- **Seven existing stations** in the network will have installed dual pulse-code modulation (PCM) telemetry facilities, dual acquisition antennas, dual digital com-

"Actually, if you can't depend on the tube, it doesn't matter at all how wonderful the theory is

behind it. The real job is to turn microwave theory—however exotic it may be—into an actual, functioning, production tube you can depend on. Without any if's, and's, or but's. For example, we're working on a two cavity klystron oscillator with an exceptionally low noise level to meet critical requirements of modern radar weapon systems. By the time the actual production model comes off the line, it will have been tested electronically, environmentally, every way we can think of. And you'll be able to trust it to operate reliably within the parameters we publish for it. I guess that sounds like a boast, but here at Varian it's standard operating procedure." *Fred Salisbury (speaking, left) and Dr. Wayne Abraham are two of the outstanding men in the Research and Development Department of Varian's Palo Alto Tube Division*



TUBE DIVISION, *Palo Alto, California* | VARIAN ASSOCIATES OF CANADA, LTD., *Georgetown, Ontario*
BOMAC DIVISION, *Beverly, Massachusetts* | SEMICON OF CALIFORNIA, INC., *Watsonville, California*
S•F•D LABORATORIES, INC., *Union, New Jersey* | SEMICON ASSOCIATES, INC., *Lexington, Kentucky*

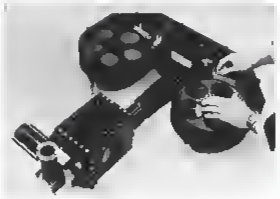
MICROWAVE TUBE GROUP VARIAN associates

mand systems and a radar coder to permit tracking of one spacecraft when it is rendezvousing with a nearby vehicle, to enable radar to distinguish between the two.

• **Unified S-band system** will be installed at the seven existing primary stations, and the new one in Australia, to permit all tracking, data acquisition, voice and television functions to be handled by a single transponder in the spacecraft instead of by the variety of equipment now required. Mercury spacecraft carried two radar beacons, one operating at C band and one at S-band; two VHF transmitters for telemetry, one UHF and one HF transmitter for voice communications, and one UHF receiver for command functions. The new unified S-band system will require a 2,300 mc transmitter and a 2,100 mc receiver in the spacecraft, plus identical back up units, to handle all these functions.

Improvements and expansions in NASA's deep space network planned for Fiscal 1964 include the following.

• **Conversion to S-band** operation from the present L-band configuration is expected to provide a 5 6 1 gain in data handling capability or improved range. Additionally, performance will be improved through installation of low noise traveling wave masers and cassegrain feeds on present 85 ft. diameter antennas.



Radiation Chamber

Radiation chamber developed by Space Technology Laboratories will be test-flown this spring. It has camera to photograph particles at speed up to one frame/sec.

• **Two additional 85 ft. antennas** will be installed, one in Australia and one in Southern Europe, to provide at least two antennas at 120-deg. separated longitudes so that more than one deep space probe can be kept continuously under surveillance.

• **210 ft. diameter antenna** will be constructed at the Goldstone, Calif., facility, the first of three planned for operational status around 1968. The new facility will extend the tracking-command range of the present 85 ft. antenna network significantly.

No widespread expansion of the present earth satellite tracking network is planned, but to handle the large amount of data expected from the orbiting geophysical and astronomical observatories, some of which will be in highly eccentric orbits with apogees of 60,000 mi., NASA plans to install 40 ft. and 85 ft. diameter automatic tracking antennas at key stations. These antennas will have X-Y type pedestals and be outfitted to operate at 136 mc., 400 mc. and 1,700 mc. The 40 ft. automatic tracking antennas will be installed in South Africa, Chile and Peru. The 85 ft. antennas will be installed in Australia, Alaska, Newfoundland and North Carolina.

• **PCM telemetry will be installed** at the new large-antenna facilities and at a few other stations to permit higher data rates.

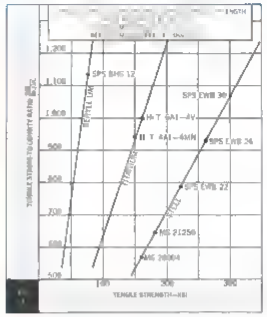
• **Automatic data processing equipment,** known by the acronym of STARS (satellite telemetry automatic reduction systems) will be installed at the Goddard Space Flight Center to permit more rapid processing of the greatly increased amount of satellite data expected during coming years.

• **New range-and-range-rate tracking system,** under development by Motorola, intended to permit more accurate position fixing on satellites operating in high eccentric orbits, is expected to be installed at three stations in the network to handle the Eccentric Geophysical Observatory (EGO).

Selecting SPS Aerospace Fasteners by Strength/Weight Criteria

No. 1 in a series of technical service bulletins

Which fastener has the greatest strength potential? Bolt for bolt, it's alloy steel hands down. But pound for pound . . . here you may want to evaluate further.



With today's emphasis on weight saving, you have to ask more of a bolt than mere mechanical strength, even when it is on the order of 300,000 psi. Certainly such muscle can be used to cut weight—and cut it substantially. But it is not automatically the best answer to your fastener design problem. Strength-to weight *ratio* is often a better criterion—and a better measure of true fastener value within practical and environmental limits.

Here is a comparison of alloy steel, titanium and beryllium bolting in terms of typical mechanical properties:

Property	Alloy Steel	Titanium	Beryllium
Tensile (psi)	308 000	168 000	75 000
Shear (psi)	190 000	103 000	65 000
Endurance limit (psi)	120 000	60 000	45,000

But look again at these same properties when divided by the relative weight of these typical bolts (results in ksi per pound per cubic inch):

Property (PSI/lb in.³)	Alloy Steel	Titanium	Beryllium
Tensile	1 580,000	1 050 000	1 135 000
Shear	672 000	645 000	385 000
Endurance limit	425 000	375 000	682 000

Obviously, when we consider fastener performance on a strength-to-density basis we have an abrupt change of criteria—and a better appreciation of the concept that in buying fasteners one literally buys KSI/lb. Fig. 1 points this up graphically in terms of tensile strength. Note particularly the relative slope of the curves—an indication of accelerating benefits you derive from materials offering higher strength-to-density ratios.

While these examples have dealt with tension fasteners, significant weight savings can be realized in shear applications as well by considering the strength to weight relationships shown in Figure 2.

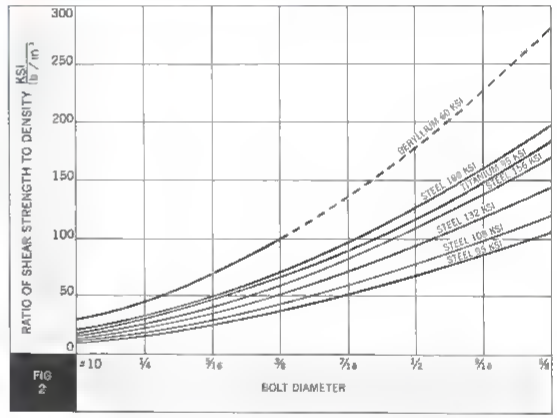
Two Possible Design Routes

All this might seem to indicate that sophisticated fastener selection calls for nothing less than beryllium in all instances. Not so, of course, for there are attendant considerations of utmost importance. Bulk, for one. Actual strength, for another.

Within the strength-to-weight concept there are two routes open to the designer: (1) Use of high strength-to-weight materials and acceptance of fastener size; (2) selecting denser materials and utilizing their commensurate strength to reduce the size of bolted assemblies.

In evaluating these alternatives, start with the premise that the higher strength-to density materials will give you more fastening power pound for pound.

Since these materials generally have lower strength potential than alloy steel, it is necessary to use a larger diameter



fastener in these materials than alloy steel to carry the same load. This relationship is shown in figure 3.

But can you afford the relatively larger hole size and bearing area? Will your materials be compatible from a corrosion standpoint? And can your fastening material cope with proposed environmental factors? If these considerations pose no problems, then your design will probably be more efficient for use of high strength-to-weight material in the fastener.

The Case for High-Density Materials

Where design limitations or fastener environment is inimical to exotic materials, or where all-out weight saving is paramount, steel is the obvious choice. And

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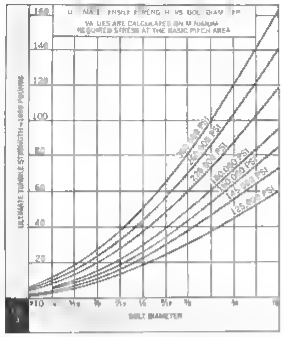


with the superbolts now available, it can be an attractive choice

Some of this steel bolting—SPS EWB 30 Series, for example—closely approaches beryllium in the strength-to-weight "spectrum." And thus it offers real opportunities to reduce fastener size, not to mention miniaturization of associated flanges, "T"-sections, etc.

Figures 4 and 5 show the current state of the art in steel fastening, as brought along by SPS. Note especially how the SPS EWB 26 and EWB 30 represent a *proportionate* increase in all strength properties, making it safe to cut back liberally on bolt diameters

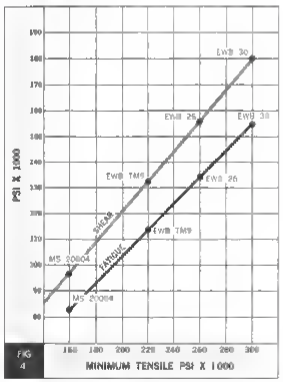


Fig 4: Comparison of EWB 30 with predecessor bolts showing proportionate increase in tensile, shear and fatigue

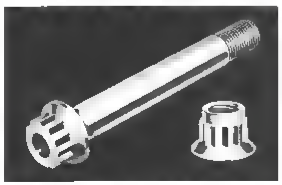
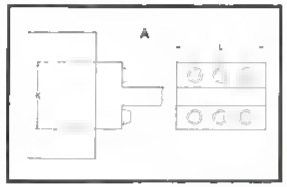
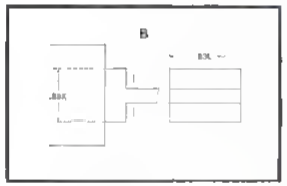


Fig 5: SPS EWB 30 bolt and companion FN 30 locknut. Tensile strength 300 000 psi

Drawings A and B give a practical demonstration of the weight savings possible with EWB 30 bolting—a clear example of how strength-to-weight ratio can also be stepped up by improving the performance of a comparatively dense material, and thus produce the dual advantages of reduction in fastener size and structural miniaturization. In this design technique an overall weight saving can be achieved, which in some cases, exceeds that of a joint with less dense fastener materials



	MS 20008 16
Bolt diam	½ in
Head diam (max.)	.828 in
Ultimate tensile (min.)	27 400 lb
Grip	1 in
Length	1 812 in
Approx weight per bolt	0 147 lb



Structural weight saving=27%
Bolt weight saving=45%

	EWB 30 6 16
Bolt diam	⅜ in
Head diam (max.)	.725 in
Ultimate tensile (min.)	28 500 lb
Grip	1 in
Length	1 739 in
Approx weight per bolt	0 0805 lb

Overriding Factors

An exception to the use of dense, strong materials can occur where shear applications employ low strength structural materials. The load transmitted by the bolt is of sufficient magnitude to cause plastic deformation of the hole in which the fastener has been used. To prevent this condition, specify a larger diameter fastener of less dense material to distribute the applied stress, keeping the unit load in the structure below its yield strength, and fastener weight at a minimum.

In seeking fastener-design answers in terms of optimum strength/weight ratio, you are bound to encounter limiting factors—good reasons for selecting alternative materials

Take the matter of plating, for example. Cadmium plate—common for steel—tends to sublime in space, causing electrical shorts, messing up lenses. Pick another plating. Or consider a corrosion resistant material

Other design considerations are the more sophisticated environmental variables that will influence your selection of a material. Can it withstand association with nitrous trioxide fuels, for example?

To avoid such problems, you may find it easier to go to a nonplated fastener (titanium or stainless steel, for example) and accept a decrease in actual tensile or shear strength

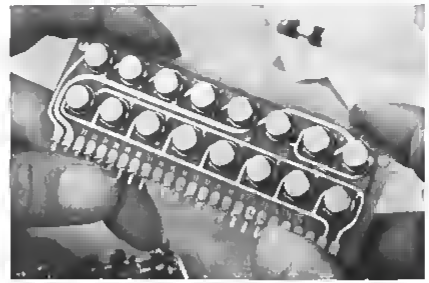
Or take temperature. At 1800-2000° you may again find it more practical to accept a lower strength-to-density ratio fastener in order to circumvent potentially troublesome coating. Use a nickel-base alloy. Or for greater strength to density, one of the refractory alloys properly coated

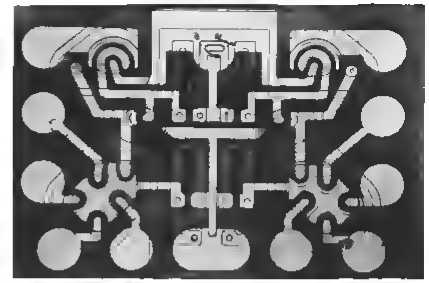
Also, you encounter specialized problems such as radioactive bombardment. Here there is a fastening material—beryllium—that offers particularly desirable properties. Beryllium is typified by a low-absorption cross section.

Obviously, for your particular design, there is one optimum fastener according to strength-to-weight criteria. For a thorough examination of every possible choice, and a recommendation, you should contact SPS.

How SPS Capabilities Can Help

Whatever your design problem or specific hardware need, SPS offers you the resources of a total capability in precision fasteners for aerospace—a capability that is unmatched elsewhere. The first successful titanium bolts, the first production beryllium bolts; the first 300,000 psi steel bolting; the first forged tungsten fasteners—these are merely highlights of a capability that encompasses the entire fastening art from research and development through production and testing to certification of reliability. For information, contact STANDARD PRESSED STEEL Co., Precision Fastener Division.





SEMICONDUCTOR MICROCIRCUITS contained in transistor cans and mounted on plug-in circuit board (left) are being substituted for conventional components by Litton Industries into the central management digital computer of the Grumman A-6A under a Navy plan to hasten introduction of microcircuitry into operational equipment. Dual nand/nor gate microcircuit (right), introduced recently by Silicon, has figure of merit of 60 pico watt-seconds, a measure of microcircuit performance.

Microcircuits Stimulate Avionic Changes

By Barry Miller

Los Angeles—Avionics manufacturers and their customers are accelerating a drive to reduce to practice the promise of microcircuitry in an effort to realize significant savings in reliability, cost, size, weight and power. There is scarcely a military agency or avionic equipment manufacturer not now immersed in at least tentative design of prototype equipment using microcircuitry entirely or in part.

Concurrently, fundamental changes in relationships between parts suppliers and users fashioned by the introduction of microcircuit technologies will become increasingly apparent.

Many of the strains besetting the entire avionics industry—increasing competitiveness, continuing vertical growth of avionics companies, overcapacity and price deterioration in the semiconductor industry—will become more acute as both microcircuit users and suppliers jockey for favorable positions in this field.

Indications that the military, particularly the Navy and Air Force, will play a pioneering role in the adoption of microcircuitry for avionic needs as they did in research and development phases, became evident last year. Primary aims of the services are a minimum of an order of magnitude increase in reliability to bring corresponding declines in maintenance costs, and weight and size reductions.

The Avionics Division of the Navy's Bureau of Weapons has notified industry of its microcircuit plans that call for the following:

- **Development models** of digital equipment with clock rates not in excess of about 1 mc delivered to the Navy after Jan. 1, 1965, to be largely, if not entirely, constructed using microcircuit techniques.
- **Production equipment** delivered after Jan. 1, 1966, employing digital circuits with clock rates not exceeding 1 mc to be largely, if not entirely, constructed using microcircuit techniques.

Spirit and intent of BuWeps' attitude will be reflected in what may be the Navy's next major avionics procurement: the avionics package comprising inertial system, central digital computer, communications and sensors of its VAX attack aircraft.

For this job, avionics companies are expected to be evaluated for their microcircuit as well as digital computer and systems capabilities. Study contractors may be selected in a competition involving, among others, Autonetics, General Electric, General Precision, International Business Machines, a Litton Industries Texas Instruments team, Minneapolis-Honeywell, Raytheon and Westinghouse. Since last summer, Litton has been developing under BuWeps contract a miniaturized inertial guidance system, believed to represent a trial cut at a VAX system. Designated AN/ASN-44, this system will use microcircuits on the gimbals of the stable platform in the navigation computer, in heading servos and power supply.

Planning is in early stages now for introducing semiconductor microcircuits into the digital computers of future Polaris missile guidance systems. Besides possible benefits in reliability, the guidance package would be reduced in size and weight, making possible an extension in missile range. The inertial navigation system of the National Aeronautics and Space Administration Apollo spacecraft is another likely microcircuit candidate (AW Jan. 14, p. 81).

USAF's improved and advanced versions of the Minuteman intercontinental ballistic missile also may incorporate one or more different types of microcircuits in their guidance systems. Autonetics, associate prime contractor for Minuteman guidance, selected three semiconductor microcircuit vendors—Texas Instruments, Westinghouse and Radio Corp. of America—to supply 119,000 circuits to be used in building prototype Minuteman guidance computers this year. Bulk of the order, for both digital and analog circuits, went to Texas Instruments, a portion of the oversupply to Westinghouse and a special Darlington microcircuit to RCA.

In addition, BuWeps is pursuing a vigorous program of experimental application of microcircuits on a piecemeal basis in existing equipment (AW July 9, p. 46) and on a prototype basis for new equipment. As part of the program, Litton Systems Data Systems Division is outfitting 26 AN/ASA-27 computer indicator systems slated for the Navy/Grumman E-2A (W2F-1) Hawkeye with eight microcircuit shift registers mounted on conventional plug-in circuit boards to make microcircuits compatible with existing equipment by the end of the fiscal year.

The Guidance and Control Division of Litton is converting to microcircuits in the central management digital computer of the Grumman A-6A (A2F-1). Sperry Gyroscope is developing a Loran C receiver under BuWeps contract using Texas Instruments semiconductor

Capabilities of Various Microcircuits

		Discrete* Circuits	Thin Film Hybrid Micro-Circuits	Semi-conductor Micro-Circuits	Thin Film Micro-Circuits**
Reliability per Function (mean time to failure, hr)	Present	10^6	10^6	10^5	—
	Future	10^7	10^7	$>10^5$	—
Price per Function (mils apiece)	Present	$20	$20–40	$20–80	—
	Future	$10	$5–10	$1–2	—
Resistance Range (ohms)	Present	$1–10^9$	$10^3–10^6$	$10^2–10^4$	$10–10^6$
	Future	$1–10^8$	$10–10^5$	$10–10^5$	
Capacitance, max (farads)	Present	10^{-6}	10^{-5}	10^{-9}	10^{-7}
	Future	10^{-6}	10^{-7}	10^{-9}	
Inductance, max (Henries)	Present	10^{-5}	10^{-5}	Negli.	Negli.
	Future	10^{-2}	10^{-4}	Negli.	
Speed (megacycles) Pulse repetition, f	Present	20	20	5–10	
Gain—Bandwidth, ft.	Present	100–400	100–400	50	~1,000
	Future	5,000	~1,000	~1,000	
Power	Present	Watts	Watts	Watts	Watts
	Future	Watts	Watts	Watts	
Ability to Breadboard	Present	Exc.	Good	Poor	Good
	Future	*Exc.	Exc.	Good	
Design to Produce Time	Present	Days	Weeks	Months	Weeks
	Future	Days	Days	Weeks	
Design and Change Flexibility	Present	Exc.	Med	Poor	Med
	Future	Exc.	Med.	Med	
Size (parts/sq ft)	Present	10^3	10^2	10^4	$>10^4$
	Future	10^3	10^2	$>10^4$	

*Figures are for semiconductor circuits using miniaturized discrete components.
**Since a thin-film active element has not yet been developed, values are listed only for those future capabilities that can be roughly estimated.

Table indicates comparative capabilities for four types of microcircuits—those using discrete conventional components, discrete components with passive thin films, semiconductor microcircuits and projected all thin film microcircuits. Table was prepared by Arthur D. Little.

microcircuits as another phase of the BuWeps program, RCA is working on a high-frequency communications receiver.

Of the several types of microcircuits available, semiconductor versions appear, on the basis of industry military acceptance, to hold the greatest promise for ultimate reliability and probable low cost. They lend themselves to batch processing and have fewer potentially troublesome hand-made interconnections among elements. Yet at the current stage of semiconductor technology, passive components are not being made without tailoring in a subsequent step to the tight tolerances usually required of components in communications, countermeasures, reconnaissance and analog gear. Consequently, this type of microcircuit lends itself more readily to use in digital circuitry where loose tolerances and temperature coefficients can be accepted, and where, because of the large number of repetitive types of circuits, batch processing can result in appreciable cost reductions.

Much of the microcircuit equipment now being built is digital. For these reasons, manufacturers planning to incorporate microcircuits can be expected to use digital circuitry as extensively as

possible, a move that will parallel the separate, steady trend toward digital aerospace equipment.

Thin film microcircuits do offer advantages in that they can be made in wide ranges of resistance and capacitor values, and tight tolerances with close temperature coefficients. Despite progress in active thin film devices, needed for a complete thin film system to be manufactured in a single vacuum process (AW Feb. 4, p. 68), these devices are years behind even quality types of commercially available transistors and diodes. The thin film microcircuit, with or without active elements, may prove advantageous in radiation environments.

For a complete thin film circuit at present, active elements must be added either in the form of discrete conventional transistors or in hybrid combinations of semiconductor microcircuits with separate passive thin film circuits or with thin films of resistors and capacitors deposited over a passivated semiconductor microcircuit.

The two techniques—thin films and semiconductor techniques—are now regarded as largely complementary, rather than competitive, following recognition by the Air Force (AW Jan. 23, 1961, p. 19) of a need for mating the best of both approaches, which is sought in a three-year program awarded to Motorola.

Increasing Vogue

Microcircuits which use the smallest available conventional components are coming into increasing vogue, although restricted because they do not promise the same high reliability and low cost as other types. Where difficult assembly techniques are not required and small size and flexibility of discrete components can be used to advantage, perhaps as potted or packaged modules, these microcircuits are appearing with increasing frequency. In sections of Minuteman's avionics where semiconductor microcircuits cannot be employed effectively, small micro-components could be applied extensively.

As an indication of industry-supported efforts, various types of airborne and ground-based digital computers using semiconductor microcircuits appeared in recent months—including computers introduced by Martin, Librascope, AC Spark Plug and Remington Rand.

If semiconductor microcircuits were to be confined to digital applications alone, their future with respect to competitive types might be seriously compromised, given the large volume of non-digital avionics equipment. Semiconductor microcircuit producers therefore, are trying to reduce manufacturing costs further by mastering of circuit masking, the high cost step in making

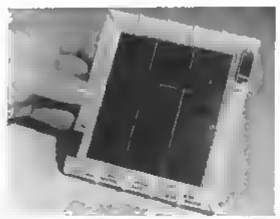
linear microcircuits. These are generally short production run items.

The Armament and Control group of General Electric's Light Military Electronics Department is developing two flight control systems that use semiconductor microcircuits to satisfy roughly 90% of the circuit requirements the company reported recently.

One combines variable increment digital computing with triply redundant majority logic voting. The other performs an analog function, making use of pulse width modulated digital signals to simulate analog values an indication of an adaptation to digital microcircuits. The latter is self-adaptive, is triply redundant and uses majority logic voting. Despite the triple redundancy for higher reliability, GE estimates the electronics of such systems, using microcircuits, would occupy half the volume of a non-redundant conventional system using a discrete component, high-packing density assembly technique.

System manufacturers delving into microcircuitry have tended to concentrate on passive thin film capability for any one of a number of reasons. These include a belief that this approach is superior or more readily adaptable at this stage to manufacturing, that it is a necessary complement to semiconductor capability to be supplied by another company division or by the traditional vendor, or that it constitutes a practical economic choice. Some companies, like GE's Light Military Department, have a complete capability for design, art work, camera reduction mask making and processing plus associated skills at the manufacturing levels.

GE says it can produce 1,000 thin film circuits of different types per factory shift, all properly subject to quality control. Similarly, Lear Siegler's In-



ThermoelectricConverter

Thermoelectric converter consisting of 36 thermoelements capable of converting the sun's heat into electrical power by the Seebeck effect has been tested by Air Force's Space Systems Division in an unidentified space shot. Made by General Dynamics General Atomics Division under Aeronautical Systems Division contract, the 4 in. x 4 in. converter generated between 1 and 1.3 watts/sq. ft. in space.

strument Products Division is producing equipment under contract in a manufacturing environment complete with quality control, inspection and support. It reports a 320 microcircuit per 5-hr vacuum cycle capability, with circuits deposited on ½ in. sq. substrates. A similar facility is installed and ready for production in Lear Siegler's Astronics Division. International Business Machines has developed a large thin film operation for the Naval Avionics Facility at Indianapolis.

Producers of semiconductor microcircuits generally are transistor and diode manufacturers or, as in the case of newly formed companies like Signetics, Siliconix and the semiconductor group of Amelco, originate with traditional semiconductor component makers. About a dozen companies today are making standard and/or custom semiconductor microcircuits. These include, besides the indicated newcomers, Fairchild Semiconductor, Texas Instruments, General Electric, Pacific Semiconductors, Motorola, Sylvania, Radio Corp. of America, Philco-Westinghouse and Raytheon.

For the semiconductor field, semiconductor microcircuits, evolving as they do from technologies perfected and nourished there, represent in large measure not only an escape from today's overcapacity and price competitiveness but also an area of future growth.

Since the microcircuit is not simply another part, but consumes some of the engineering and design that the user previously added in making his product and from which the user derived a portion of his profit, it is not certain that he will stand by and permit his former suppliers to usurp a portion of his business. Major avionics equipment and systems manufacturers have wrestled with this problem recently and are making decisions about what course to follow.

Some may want to acquire the capability for any combination of reasons. These include a desire to retain circuit design prerogatives, an interest in remaining on a favorable footing with competitors which have this capability, belief that it may be a prerequisite for securing military business, or a desire to broaden product bases and thereby boost volume. Most semiconductor companies in the microcircuit business are divisions or subsidiaries of equipment manufacturers, which offer a convenient market and which loom as challenging competitors to other, less-well-equipped manufacturers.

A number of aerospace companies such as Antonetics and Litton are choosing what may be a middle ground—starting an in-house R&D capability in semiconductor microcircuits. For companies of this type, the consulting firm of Arthur D. Little, which recently surveyed these problems, sees these advantages to such in-house capability:

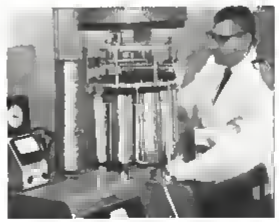
- **Contractor** can stay abreast of developments and, if necessary, take an active lead.
- **Contractor** can qualify for, bid on, evaluate, specify, buy, test, install and guarantee microcircuit equipment.
- **Contractor** can, with slight additional investment, move into production of microcircuits. An R&D facility, Little notes, can produce surprisingly large quantities of such devices if it is required to, making possible an easing into microcircuit production.

Little expects one computer manufacturer accounting for 70% or more of the commercial computer market to integrate downward, providing itself with complete microcircuit capability and thereby absorbing in itself a sizable portion of this potential market.

Tendency for the large equipment maker to do it himself will severely bind the independent microcircuit producer. Markets for the independent would center principally with small users unable to afford in-house capability, making too diverse a range of products to allow further standardization and thus preventing price reductions to stimulate more extensive use.

Semiconductor microcircuit producers are vigorously seeking footholds as suppliers in most of the early microcircuit equipment programs. Some have chosen to hold their shots for programs they believe will reach production, but they appear to see their future in this business linked to ultimate close participation with the user on specific projects.

Many have introduced standard



Microcircuitry Facility

New microcircuit development facility recently opened by General Electric's Light Military Electronics Dept., Utica, N. Y., includes multiple turret thin-film deposition chamber with eight cylinders each of which contains different mask and materials and can be remotely controlled. New GE laboratory has facilities also for producing semiconductor microcircuits and combination (hybrid) devices. The 6,000 sq. ft. laboratory complements microcircuit manufacturing facility opened six months ago.

Mobile Tropo-Scotter Antenno Built

Mobile tropo-scatter communications antenna is built from plume structural elements which form the trailer that carries antenna when disassembled. Note two rubber tires (arrows) which form part of trailer. The novel antenna, called Mobitenna, was built by I-T-E Circuit Breaker Co. for Army. It weighs 9,600 lb., can be erected by four man crew in six hours and has a 28-ft. dia. parabolic reflector.

microcircuit products and one or two, like Fairchild, have enjoyed considerable sales success. Some, like Motorola, Signetics, and Fairchild, supply individual semiconductor components made on separate chips which the customer breadboards as he wishes and returns to the producer, who duplicates the circuit in microcircuit form. Others, like Texas Instruments, General Electric and now Signetics, offer arrays of transistors and resistors fabricated on a silicon slice (AW Aug. 27, p. 69), permitting the customer to specify which are to be connected into desired circuits in a subsequent, custom processing step.

Each of these steps is looked upon as a necessary interim phase in introducing microcircuits to the industry. Eventually, producers hope to approach manufacture from the point of view of the circuit function, rather than as a component for component replacement. In this way, they feel, the semiconductor processes can be utilized more efficiently.

One factor which may help present producers to take and hold a lead in microcircuit design is the need for various logic organization systems to sidestep low component tolerances in semiconductor microcircuits. Each of these appears to have relative advantages in terms of power dissipation, signal delay time and noise rejection, but since most are new to digital circuit designers, the producer is taking the initiative in a circuit design area. This will necessitate an even more close working relationship between the producer and the user in translating the latter's requirements into proper circuits.

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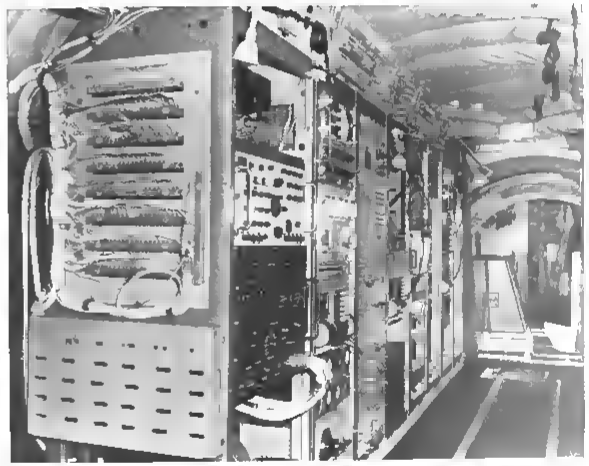
DC-4 Monitors Cape Launches

Radar equipped DC-4 is being used by the Avco-Everett Research Laboratory to monitor downrange ballistic missile launches from Cape Canaveral. Program is being sponsored jointly by the USAF Ballistic Systems Division and the U. S. Army Materiel Command. Electronics equipment (right), is composed of optical and electronic installations for measuring ballistic missile re-entry phenomena. Data will be used in the development of discrimination techniques for the Nike-Zeus anti-missile system. Aircraft is based at Ascension Island and is operated under contract to Bell Telephone Labs for whom Avco is furnishing the data. Below, left, radar receiver which measures ionized wakes of re-entering ICBMs is shown. Below, right, Avco technicians photograph an incoming ICBM



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Marine Sikorsky HSS-2Z modified for presidential mission flies over Washington. Jefferson Memorial is in foreground, Washington Monument at upper left.

Helicopters

FLOTATION CAPABILITY of the Kaman UH-2B (HU2K) SeaSprite is tested in the Connecticut River near Kaman's Bloomfield plant. An HH-43B Huskie in the background monitors the test operation.

Helicopters Facing V/STOL Competition

By David A. Anderton

Vertical-lift segment of the aerospace industry must look forward to the early and necessary solution of many problems before it can hope to grow much beyond its present status as a useful military and a limited civilian workhorse.

The bright promise of the small gas turbine, once heralded throughout the helicopter field as the way out of most of the difficulties, has led to a series of new problems, not all of them replacements for the ones that were faced when reciprocating engines provided the power.

Helicopters here and abroad continue to establish new records for speed, payload and payload to altitude, but these are records only when judged against other helicopters, and don't begin to compare with the performance of fixed-wing aircraft with the same kind of installed power. However, the helicopter is the only aerial vehicle able to deliver operational vertical lift capability.

Together the United States and Canada—the two countries where the helicopter has been used most extensively and successfully—register less than 1,000 rotary-wing craft. Their combined registry of fixed-wing aircraft approximates 100 times that figure.

Development of VTOL and STOL aircraft types has shown performance approaching the helicopter in a vertical sense and surpassing it in horizontal dimensions. These specialized aircraft are designed to operate in the current environment of fixed-wing aircraft; they won't require special airports, although they will use them if they are available. Most of the current crop of developmental VTOL projects are being designed to work out of standard heliports, these latter facilities, once thought to be simple squares the size of a tennis court, have grown to be more complex and to the area of a foothill field.

These problem areas serve to define the dilemmas facing the rotary-wing industry. These are problems that exist now and must be solved in order to achieve some of the bright future that has long been predicted for the helicopter.

This is not to say that the helicopter segment of the industry has been marking time, or that it is at the bottom of a technical trough. There are bright areas of individual progress which strike sparks.

Lockheed's work with the rediscovered rigid-rotor principle has opened the eyes of other companies which discarded this concept some years ago. Even though Lockheed has thrown a proprietary curtain over its YH-51A, some word about the performance of the unconventional craft has filtered through. It has been enough to drive other designers back to the file cabinet and then to the drawing boards for a second long look at the technique.

Bell has been a strong proponent of the rigid-rotor system also, and a modified Bell helicopter has been flying as a testbed for the system. The differences between Bell's and Lockheed's proposals in the rigid-rotor system is more properly argued on a semantic level with a definition of the word "rigid."

A truly rigid rotor, like an infinitely stiff wing, is a device existing only in the mind of a structural designer who wants to reduce the large number of variables in the structure by at least one. He assumes an infinitely stiff structure, even though he knows that it deflects under loads. The deflections he notes, are assumed small and therefore negligible.

The rigid rotor starts by not having a flapping hinge. That makes it stiffer than a flapping rotor, but it doesn't make it rigid. The degree to which the rotor is stiffened is still a matter of individual definition of rigidity. Both Bell and Lockheed have, in their own terms, rigid rotors.

So far, the most spectacular results of both programs have been some startling pictures showing the ability of each vehicle to cope with large center-of-gravity travel. Bell's rigid-rotor helicopter has been shown hovering while Chief Engineer Bart Kelley hung from the trusswork of the fuselage out near the tail rotor.

Lockheed has shown motion pictures of its CL-451 test vehicle with a bar rigged perpendicular to the fuselage at the cockpit. From this bar was suspended a trapeze, and on the trapeze sat a large man, who swung back and forth while the helicopter was hovered and flown.

Both these demonstrations are stunts, like the engine-out flybys at Farnborough or the Paris Air Show. From the outside they look impressive and

they certainly make the point, but the observer doesn't see how hard the pilot may be working and doesn't know how the aircraft was loaded.

But the ability to perform stunts does not detract from the very real advantage of the rigid-rotor system. Its ability to handle large variations in center-of-gravity position makes the system a strong contender for future designs where indiscriminate loading, or sudden changes in loading, are requirements. Examples of the former are transport helicopters of the latter, an armed helicopter which discharges its armament suddenly.

Bell supplied another bright spot during the past year with its detailed development of a high-speed concept applied to its UH-1 model (AW Dec. 10, p. 52). The use of an improved rotor system, with changed mechanical parameters, plus a streamlined fuselage and cleaned hub and mast, raised the speed level well above the routine velocities usually reached with the type.

This basic improvement of an existing aircraft, which was done partly by redesign and rebuilding, and partly by filling in the gaps with foam plastic and glass fiber, points the way to a further development of a "clean" helicopter starting with the first lines of a new design.

Progress in the Army's light observation helicopter program gave some impetus to rotary-wing development during the past year, although it is much too early to say which of the three competing types—Bell, Hiller and Hughes—has contributed most to the state-of-the-art. Earlier problems with the powerplant for the LOH series—the Allison T63 turboshaft engine—caused some forced draft engineering at the Indianapolis manufacturer's plant, and gave added emphasis to the development of an alternate powerplant, the Continental T65 (AW Feb. 18, p. 79).

In a few months from now, Army will have to decide what to do with the entire LOH program, which started out to be a competition for a single airframe and a single engine, and now involves three airframes and two engines. Army, which has much modernization to do in many of its vehicle designs, may be pressed for enough funds to carry the LOH program at the levels originally envisioned when its proponents were talking in terms of several thousand helicopters.

Increased Army interest in the Bell Warrior concept (AW Feb. 18, p. 26) may further dilute the money available for LOH funding. Such a concept, if developed, is going to be essentially a rotary-wing fighter, especially designed for escort of slow and vulnerable troop carrier helicopters in Vietnam and similar situations.

The Navy has financed development of advanced, gas turbine powered helicopters for its search and rescue and anti-submarine tasks. First units of the Sikorsky SH-3A and Kaman UH-2A have gone into service with the fleet and are providing the Navy with its first operational experience with high-density, gas-turbine, electronically sophisticated helicopters.

The Air Force continues to give little support to the helicopter, largely continuing purchases of Kaman HH-43Bs for rescue work, a role in which this gas turbined aircraft has covered itself and its flight crews with distinction. USAF also is buying the Sikorsky S-61R, a rear-loading version of the Navy SH-3A on an interim basis in its SOR 190 program, and may increase its helicopter inventory for missile site support.

Problems of New York Airways have not added to the helicopter's luster. Two forced landings in the waters of New York Harbor have led the list of teething problems of the gas turbine powered helicopters going into service with the carrier and have often forced the use of substitute piston equipment. But lack of equipment happens less often now, and load factors recently have increased.

New York Airways shares with three other lines—Chicago Helicopter Airways, Los Angeles Airways and San Francisco & Oakland Helicopter Airlines—the distinction of being the only helicopter common carriers in the United States.

The great advantage of the helicopter airline is the saving of time, for the traveler who has to make a schedule and is willing to pay the high fare in order to do so. Even with relatively high fares, subsidy requirements remain substantial, and cuts sought by Congress are restricting additional acquisition of turbine-powered equipment.

The helicopter airlines have another problem, too. When they were first organizing, they laid out a network of routes into the suburbs, against the day when they could function as a high-speed transportation network, feeding passengers to the airlines at the metropolitan airports.

By and large, these networks exist today only on paper.

In some cases, an occasional city did build a heliport, and opened it, with appropriate fanfare, to helicopter traffic. Typical of these was Paterson, N. J., an industrial city about 25 mi. from the nearest commercial New York airport. A helicopter taxi service moved in, and shortly after moved out for lack of customers.

In Ridgewood, N. J., half-a-dozen miles to the north, there are plenty of potential customers. According to one survey of the town's business travelers, almost 100 men leave on a business trip every day, and most of them travel by

MODIFIED BELL UH-1B used in high-speed helicopter research is cleaned up extensively with fairings to reduce drag. Also under investigation is a tilting rotor mast.

HILLER OH-5A Light Observation Helicopter entry flew for the first time this year. Bell OH-4A (below) was first of the three LOH entries to fly.

USAF IS FUNDING prototype development of Curtiss Wright's X-200 four engine VTOL transport, shown here in mockup form. USAF designation is X-19.

air and require transportation to the airport. But Ridgewood officials were among those who called the helicopters noisy and dangerous, and that suburban village remains without a heliport and rotary-wing service.

These typical reactions probably go a long way to explaining why one of the major functions of the Vertical-Lift Council of the Aerospace Industries Assn. has been one of public education and promotion of helicopters and heliports. Yet as hard as the council worked last year at the development of heliports, the only tangible results have been a site selection by Hartford, Conn., and site surveys initiated by two other cities.

There were 720 established heliports in the U.S. as of last year; this figure represents a 50% growth over the previous year. But the number includes privately owned sites, such as factory stops, and so does not reflect the extent of commercially usable heliports in this country. Statistics published by the Vertical-Lift Council also include 100 oil rigs in the Gulf of Mexico, and 225 heliports and 2,500 unimproved helistops used by the U.S. Forest Service. But none of these adds to the score of commercial stops, either.

During 1962, both the number of helicopter operators and the number of helicopters in service increased considerably. In 1962, 322 operators flew a total of 994 helicopters in the U.S. and Canada. Helicopter flight schools increased from 55 the year before to 85 last year, reflecting both the increased interest in getting a helicopter rating, and the optimism in the future of rotary-wing craft.

Military Use

On the other side of the world, the anti-guerrilla action in Vietnam was being spearheaded by the oldest and youngest helicopters in the Army units: the Vertol CH-21 series and the Bell UH-1 series. Both these types were praised for the job they were doing, which no other type of aircraft could do, both shared criticism directed vaguely at maintenance or vulnerability, without too much in the nature of specific charges. But some of the lessons of the Korean War a decade ago had been learned, and the current helicopters are being used in ways that were unimagined then. Loss rates in Vietnam were criticized by public officials, but countered by Army officers, who explained that their combat-loss rate was considerably lower than their in-training rate or even normal attrition (AW Jan. 7, p. 27).

Planners are also looking forward to the time when they can incorporate tactical VTOL aircraft into their plans. Major step in that direction was the awarding of the XC-142A VTOL transport to a team of Vought, Hiller and Ryan. Last fall, the mockup of the aircraft was reviewed and approved with minor changes. Detail design of the XC-142A is working toward a peak now and the program is on schedule (AW Jan. 14, p. 60).

There were some problems in connection with the award, though. After it was announced that the team had won the tri-service VTOL transport competition, one of the services—the Navy—pulled out to sponsor its own idea of a winner. The Navy had not favored the tilt-wing approach, and decided instead to fund the development of the Bell X-22A, a vehicle using four ducted fans and officially classed as a research aircraft of the variable-stability type (AW Oct. 1, p. 38).

X-19 Completion

Air Force also put some of its money into the completion of the Curtiss-Wright X-19A, an unusual VTOL type featuring four small-diameter rotors which use the radial-force principle to amplify their normal thrust into VTOL performance (AW Aug. 6, p. 64).

Thus the original tri-service transport competition, planned to effect economies by having a single type of VTOL transport for all three services, may be headed where most of the skeptics said it would end—in three separate programs.

In another type of VTOL aircraft, Ryan and Lockheed-Georgia are competing against each other and the now-flying Hawker P.1127 for a possible Army order for a reconnaissance aircraft. Ryan's design, the XV-5A, uses a General Electric X353-5 lift-fan powerplant, with two six-foot diameter fans installed in the wings of the craft, tip-driven by the exhaust from a pair of GE J85 turbojets. The thrust of the turbojets can be diverted to provide propulsion for forward flight after the transition from the vertical takeoff mode into horizontal motion (AW Jan. 21, p. 64).

Lockheed is using the principle of the ejectors to obtain large thrust for vertical lift. The JT12As in the XV-4A blast their exhaust out through a manifold that resembles some ancient mammal's backbone, and aspirate enough auxiliary air to generate the necessary lifting force.

Hawker's P.1127 uses a Bristol Siddeley Pegasus engine, which has four swiveling nozzles to divert the exhaust through a range of angles from directly aft to down and slightly forward of the vertical. Thus British aircraft, which carries a DOD designation of XV-6A, has one advantage over both the Ryan and Lockheed types: it has been on flight status for the better part of one year, and has performed many transitions, has flown supersonically, and

most recently has made carrier landings.

Later this year the Lockheed model will complete its transition tests—it has been flying for some months now in a conventional manner—and the Ryan design will take to the air. A competitive fly-off will complete the Army's evaluation of the three aircraft with the winner hopefully to get an order for more. This also will involve politics, because a reconnaissance aircraft easily becomes a reconnaissance/strike aircraft with the addition of a few simple external stores. The Air Force can be expected to protest infringement into its strike mission. Should the Hawker design be favored, there would also be expected complaints from officials who feel that buying American should be the rule.

Ground Effect Machine

Finally, off in one corner of the vertical lift flight envelope is the ground-effect machine, a vehicle which has been described as being ideal for travel and transport where it has no other competition.

The early development of vehicles in this field got off to a good start a few years ago, with the backyard construction of literally dozens of machines which proved little more than the principle involved. Now the engineers have taken over, and the ground-effect machine is beginning to produce some results.

Most publicized was the use of the British Hovercraft in limited ferry service across the River Dee estuary. In this country, Bell has developed contracts for a Hydroskimmer, primarily a water-based vehicle for the Navy, plus a development contract from the Port of New York Authority for a prototype vehicle which could function as an emergency vehicle in the soggy marshes off the ends of New York airport runways.

Marine GEM

Deliveries of GEM vehicles have also been made by National Research Associates, which has built a gas turbine vehicle for the U.S. Marine Corps.

But GEM vehicles suffer in the U.S. from too much competition from other types of vehicles. Roads, waterways and airways are far more developed here than anywhere else in the world; the GEM is at home off the roads, off the waterways and near the ground. Over a swamp it can beat the swamp buggy or the various thrust-driven sleds that have been used.

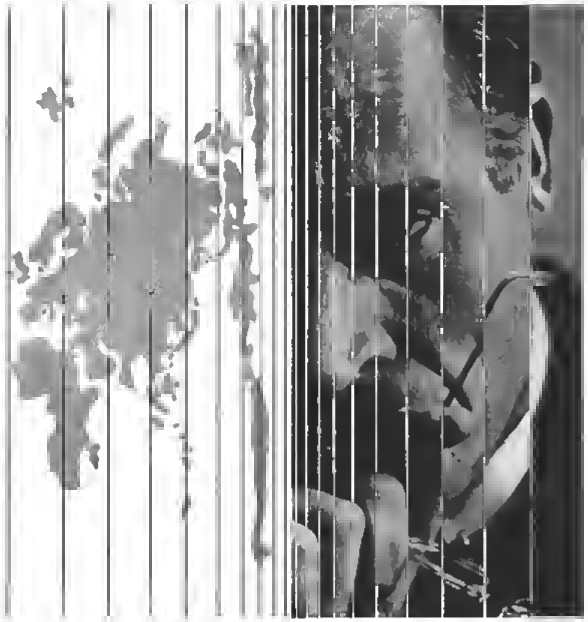
It might prove an answer to Arctic transportation problems which still confront the military.

The military has been unable to find any other vehicle better for carrying out this type transportation than the now-obsolescent Weasel.

Looking ahead, then, the entire vertical-lift industry has a tough job to accomplish.

Today's helicopters, aside from detail design refinements, haven't really changed much in the 20 years since Igor Sikorsky eased his machine off the ground and pioneered the new form of air transportation. The blades still flap and cone and lead and lag; the forces they transmit to the hub and the mast and gearbox are complex and still incompletely understood. Payload to gross weight ratios have improved considerably, but autorotative descent speeds have not decreased. A few materials have been changed, here and there; some rotors have glass fiber blades, titanium shows up in the engines. Gear boxes are better than they used to be. Vibration levels are decreased, but still very much present. The hovering helicopter is still unstable, and in spite of some major developments still is not an all-weather aircraft in the full sense of the word.

But continued, growing military helicopter programs also underscore the unique utility and potential of the rotary-wing vehicle.



Compressing Real-Time Human Effectiveness

—one approach is to roll back two boundaries of the command and control data problem: the amount of information that can be reliably gathered and stored . . . and the amount that can be presented to the human decision maker in real-time without exceeding the threshold of human saturation.

An illustration of this double-barreled systems approach may be seen in the Strategic Air Command Control System 465 L, for which ITT International Electric Corporation is Prime Contractor.

Data enters the 465-L network from Remote Communication Centrals all over the world. Each RCC can accommodate as many as 1,500 messages per hour by means of up to 32 input/output devices. All messages transmitted within the System are automatically routed, recorded, and error-checked by Data Transmission Control Centers located at each SAC Headquarters. Information flows into the Data Processing Central, where a high-speed computer compares events reported by RCC's with plans stored in its memory. The DPC will automatically alert the SAC staff to any significant deviation between actual and planned events.

At the critical man/465 L interface, assimilation of the vast quantities of information funneling into SAC command centers has been greatly enhanced by a recent ITT development—data presentation in color. Operating at speeds that appeared incredible only a short time ago, the new display system enables computer outputs to be converted to alpha-numeric form . . . photographed . . . developed and projected onto 16 large control center screens in as many as 7 colors in a matter of seconds.

If you tour our Paramus, New Jersey facility, you'll find a complete operational prototype of 465 L, occupying over 20,000 square feet in one of our buildings. This unusual installation can also be used to simulate almost any command control or information system our engineers wish to study . . . military or commercial.

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PROGRAMMERS/ANALYSTS. For real-time programming analysis and development. Broad activities encompass advanced programming systems, including special color display routines, diagnostic programs, automatic recovery, problem-oriented language, artificial intelligence.

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Aero Jet Commander, newest competitor in the turbine-powered business plane market, takes off for the start of its flight test program.

Business Flying

CESSNA MODEL 336 SKYMASTER is powered by tandem-mounted 210-hp. Continental IO-360-A engines, carries 4-6 passengers.

Business Plane Sales Curve Edges Higher

By Erwin J. Bulban

Dallas—Business aircraft manufacturers predict over-all dollar volume will increase 10% in 1963 over last year's factory billings of $180 million and aircraft delivered will exceed 1962's total of 6,697. If these predictions are borne out, it will indicate business flying's growth curve, interrupted two years ago, has resumed its general upward trend of the past decade.

For all this show of strength—in the last 10 years airframe builders have delivered 60,000 business airplanes valued at approximately $650 million wholesale—there are signs of impatience with this growth pattern. Some feel that prosperity de-emphasizes problems that are actually holding business flying far below its potentials, to at least half or a third of the level it should be achieving.

Never before have customers had such a wide variety of aircraft and equipment to choose from, with more on the drawing boards and in flight test. And never before has the over all environment to encourage flying—the availability of navigation and communications aids, general business prosperity and income levels—been so favorable.

But there is wide agreement that in the area of point of purchase, in selling the goods, the picture needs considerable brushwork to match the quality of the product.

Cessna Survey

A survey by Cessna Aircraft Co. indicates that 98.6% of the business aircraft market is untapped.

The problem is basically good salesmen and the industry simply hasn't found enough of them to fill the demand. Richard Robinson, Cessna domestic sales manager, points out that a nose count of the people actually selling aircraft shows how thin their ranks are. The number breaks down to one full-time airplane salesman to every 500,000 persons in the United States. Even disqualifying large chunks of the population to increase the ratio of salesmen doesn't begin to bring it to terms where the market potential is even being scratched, he contends.

Since the industry generally is concentrating on technological quality, acquisition of new salesmen and retail outlets has been slow and frustrating. Beech Aircraft Corp. now expects to fall far short of its goal of 188 retail outlets by October, an expansion based primarily on exploiting its entry in the low-cost field, the four-place fixed gear Musketeer. This probably will mean cutting back plans for first year production of the new airplane by 100 units, although Beech still expects to build 700 in its Fiscal 1963 sales year.

Other critics within the industry believe that the big push to build airplane sales outlets and their attendant service operations, while curing one problem, creates another and cuts the ground from under a fundamental building block in business flying's foundation.

This is training. Frank Martin, Cessna marketing division manager, notes that efforts to build retail outlets have lured many a first-rate flying school operation into aircraft sales. Student training, as a result, has suffered.

This is happening at the time when public interest in flight training is growing, when flight schools should be encouraging this trend.

Airframe manufacturers have a more than academic stake in building this segment of the business. Statistics indicate that at least one of every five students buys an airplane on getting a license. By improving pilot proficiency and increasing the number of instrument flight qualified pilots, training develops market potential for more sophisticated, costlier aircraft.

Other Opinions

Another Cessna executive who believes the training program is getting "soggy" is Senior Vice President Del Roskam. He feels that manufacturers must take some of the load off the operator. One approach would be development of new teaching methods to simplify the training job, thus cutting time needed and reducing costs.

Use of audio-visual techniques has shown that ground school work can be halved, without any apparent detriment in the quality of teaching. Roskam feels

PIPER APACHE 235 4-5 place light twin cruises at 191 mph at 7,000 ft at 75% power

U. S. Military and Commercial Aircraft and Engine Shipments

Aircraft	1961	1962	1963 (Forecast)	Per cent change 1961-62	Per cent change 1962-63
Value of shipments (thousand dollars):					
Complete aircraft for U.S. military customers	3 287 397	2,660 000	2,650 000	− 4	0
Complete civilian aircraft [1]	865 324	970 000	680 000	+ 2	−30
Utility and executive aircraft [2]	124 000	190 000	160 000	−27	+19
Commercial transport aircraft	850 000	800 000	480 000	− 6	−40
Rotorcraft	9 000	10 000	10 000	+11	0
Units shipped:					
Complete aircraft for U.S. military customers	2 000	2 000	2 000	0	0
Complete civilian aircraft	7 402	6 850	7 300	− 8	+ 7
Fixed-wing	7 101	6 550	6 980	− 9	+ 7
Multi-engine	1 153	1 150	1 280	0	+11
30-plane and under [3]	963	1 000	1 200	+ 4	+20
31-plane and over	180	150	80	−27	−47
Single-engine	6 024	5 400	5 700	−10	+ 6
3-plane and under	2 207	1 300	1 200	−41	− 8
4-plane and over	3 821	4 100	4 500	+ 7	+10
Rotorcraft	291	300	320	+ 3	+ 7
Value of imports (thousand dollars)	82 871	55 614	35 000	−22	−37
Value of exports (thousand dollars) [4]	339 962	345 874	250 000	+ 2	−28

Engines	1961	1962	1963 (Forecast)	Per cent change 1961-62	Per cent change 1962-63
Value of shipments	348 523	315 000	355 000	−10	+11
Civil aircraft engines	213 698	165 000	175 000	−22	+ 6
Reciprocating	26 100	25 000	30 000	− 4	+20
Turbine	186 598	140 000	145 000	+25	+ 4
Civil aircraft engine parts	135 825	150 000	180 000	+10	+20
Units shipped					
Civil aircraft engines	11 113	11 000	11 000	− 1	0
Reciprocating	10 188	10 400	10 500	+ 2	+ 1
Turbine	925	600	500	−35	−17
Military aircraft engines [5]					
Reciprocating	500	500	500	0	0
Turbine	4 900	5 000	5 000	+ 2	0
Value of imports [6]	17 485	12 306	10 000	−30	−19
Value of exports [6]	207 808	265 000	220 000	+27	−21

[1] Includes military type planes shipped to other than U.S. military customers, e.g., to foreign governments.
[2] Breakdowns under this total are BDSA estimates based on data from government and industry sources.
[3] Includes executive and other transports for other than commercial use.
[4] Complete civilian and commercial aircraft. Data on military aircraft are included in the basket category "Aircraft parts and accessories n.e.c."
Source: Bureau of the Census.
[5] Value not available.
[6] Includes military aircraft engines and parts and all other reciprocating and turbine engines and parts.
Source: Bureau of the Census, Bureau of Labor Statistics, Federal Aviation Agency.

that manufacturers, working with Federal Aviation Agency, could study the use of programmed learning, so-called teaching machines, to make further marked reductions in training time, to the benefit of students and instructors.

That interest in flying is at an all-time high is indicated by manufacturers' fan mail. Cessna and Piper now are each averaging 20,000-25,000 inquiries a year.

Desire to own an airplane has developed to a high peak, sharply reducing former aircraft attrition rates because of failures to relicense.

Where it took seven new airplanes to add just one additional plane to the active general aircraft inventory in 1955 and prior years because of the high drop-out rate, Cessna estimates that average attrition now is in the neighborhood of 2.7.

Backed by particularly favorable first quarter sales reports by the industry's leaders, Beech, Cessna and Piper, and few field inventories again this year, the 10% dollar volume gains forecast by manufacturers appear reasonable perhaps conservative.

Field inventory figures actually have manufacturers concerned that retail outlets have grown complacent. This feeling persists despite the fact that, in Cessna's case, the company reports orders from the field for the next three months exceed those in the same period of the past two years. First quarter retail sales figures indicate a trend bettering last year. Cessna's retail sales were 18%-20% over the same period last year and they exceed the company's projections by 8%-10%.

Big emphasis in sales will continue to be on the light twins. Growing popularity of these larger, more sophisticated aircraft with their two-engine safety factor is largely due to increasing availability of lower-cost electronic communications and navigation equipment.

Last year, FAA plotted 9.9 million cross-country trips by general aviation aircraft compared to 7.1 million by scheduled air carriers. In the past five years general aviation aircraft trips have increased by 2.5 million while air carrier levels have remained the same. Particularly significant is the fact that these trips were recorded from only the 250 airports where FAA operates control towers.

General aviation aircraft operate from 6,000 airports, while the airlines serve less than 600.

Sales of twin-engine business aircraft last year totaled 1,007 units, compared to 936 the year before and it can be expected that 1962's figure will be exceeded markedly this year and next. To prepare for more future business in this area, the top airframe builders are planning additional new models in the lower and higher ends of the present price and performance range.

Cessna last year did more than 20% of the total business of the four prime manufacturers in this class and is aiming to capture 50% of the twin business in the next few years. Deliveries of Cessna's 4-6 place twin-boom tractor pusher Skymaster will begin in May in a campaign at the low priced end of the twin market aiming to unseat Piper from domination of this category held for so long with the Apache. Piper, aware of the threat from the Skymaster, plans to counter with a twin-engine version of its Comanche four-seater, a major development project at its Lock Haven, Pa., plant scheduled for production this year.

With 600 domestic retail sales outlets between them, these two light-twin protagonists should produce a major impact on this market, eclipsing previous sales marks. Although not all of their sales outlets are capable of taking on this class of airplane, both companies are planning to expand the number of dealers currently capable of handling them.

The battle is going to get hotter in the higher-priced end of the multi-engine scale as Aero Commander, Beech and Cessna bring out new airplanes. Next month Aero Commander will start deliveries of its Grand Commander 12-place twin with fuselage stretched 6 ft. 2 in. and priced at $173,500 in the standard version. The new Grand Commander competes directly with the Beech Queen Air. Beech already has an improved version of the Queen Air in the works, featuring a pressurized fuselage. Deliveries are to begin early next year. Indications are that Beech has expanded its initial plans for this airplane and that there will be even further changes than pressurization—enough to permit the airplane to be offered as a completely new addition to the Beech sales line, emphasized by a new name.

Beech may also be countering the forthcoming Cessna 411 twin another 1964 product. Sources close to both the new Beech and Cessna projects say that they may emerge looking so much alike externally that the exterior paint scheme designers are going to be hard put to establish product distinction.

In the course of widening product lines and waging the battle of the twins, there is a particular product area that seems not to have kept pace with model improvement. This is the so-called heavy single-engine airplane and it is here that manufacturers are working to produce an airplane that will boost prestige of this class. Few will yet tip their hands but it is certain that Mooney, Cessna, Piper and Beech have airplanes in development to update markedly the Mark 20C, 210, Comanche and Bonanza, respectively. Piper is known to be coming out with a 400-hp version of its 250 hp Comanche this year, Mooney

U. S. Business & Utility Aircraft Shipments—1962

(Number of Units, Builder's Net Billings—thousands of dollars)

Make and Model	January	February	March	April	May	June	July	August	September	October	November	December	Totals
Aero Commander 500A, B	6	8	7	3	1	3	5	2	2	8	10	8	62
560F	5	1	1	0	3	3	2	2	1	0	0	0	18
680F	4	4	1	0	0	3	0	3	2	1	1	1	30
680FP	0	0	0	0	0	0	0	0	0	0	1	2	3
	$1 318	$1 323	$770	$723	$1 137	$929	$1 197	$881	$818	$787	$989	$944	$10 946
Beech 18 Super	2	2	4	0	1	1	2	2	1	5	8	8	36
23 Musketeer	0	0	0	0	0	0	0	0	10	37	36	42	124
33 Debonair	16	15	21	16	19	17	13	11	10	9	3	6	156
36 Bonanza	16	21	16	13	22	16	17	10	12	12	19	16	202
50 Twin-Bonanza	2	3	4	3	2	2	2	1	1	2	3	3	30
95 Baron	17	13	10	13	16	10	12	10	14	7	11	11	152
95 Queen Air	4	3	1	0	2	2	2	1	1	2	1	0	19
99 Queen Air	0	0	2	1	0	7	0	0	0	0	0	3	01
88 Travel Air	3	2	2	2	0	3	3	2	4	2	1	1	30
MS-760 Paris	0	1	0	0	0	0	0	0	0	0	0	0	1
	$2 767	$2 506	$3 228	$2 662	$3 222	$3 278	$3 179	$3 182	$2 781	$3 860	$3 323	$3 223	$37 256
Cessna 150	36	22	26	24	32	29	35	33	13	50	19	27	319
172 Skyhawk	32	41	61	70	78	50	47	40	30	231	109	91	871
P172	0	0	0	0	0	0	0	0	0	0	5	7	12
175 Skylark	0	12	0	0	3	4	0	4	1	3	0	0	80
180	0	0	12	12	10	22	0	0	0	11	0	10	122
182 Skylane	59	53	110	90	79	58	72	45	46	11	0	110	824
183 Skywagon	28	29	25	26	10	25	21	14	9	14	11	10	228
205	0	0	0	0	0	0	0	0	32	40	36	40	168
210	29	51	44	42	29	10	14	14	7	8	1	30	281
310	12	25	10	11	10	10	14	5	13	7	0	20	164
320 Skyknight	6	9	0	2	4	3	1	2	10	9	0	2	84
	$3 786	$3 782	$5 150	$4 204	$4 870	$4 184	$3 131	$2 567	$3 558	$5 043	$2 651	$5 786	$50 181
Champion 7EC Traveler	1	0	1	0	0	2	1	0	0	0	1	0	5
7FC Tri-Traveler	0	0	0	2	0	1	0	0	0	0	0	0	3
7GCB Challenger	4	1	0	3	10	0	0	0	0	7	0	0	25
7GCBA Agricultural	0	0	0	0	0	0	0	0	0	2	1	1	4
7HC DX'er	2	0	0	0	0	1	0	0	0	0	0	0	3
	$45	$6	$66	$30	$73	$57	$82	$80	$50	$70	$73	$56	$588
Lake LA-4	1	0	1	1	1	1	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	5
	$20	$6	$20	$17	$23	$21	N.R.	N.R.	N.R.	N.R.	N.R.	N.R.	$107
Mooney Mark 20C	21	27	34	33	38	38	38	39	39	34	32	32	397
	$312	$384	$480	$459	$529	$540	$540	$546	$550	$522	$498	$485	$5 525
Piper PA-18-A Super Cub	15	11	17	11	12	14	7	13	9	11	11	10	131
PA-22-108 Colt	39	24	43	41	11	10	13	35	22	34	31	19	322
PA-22-150 Tri-Pacer	0	1	0	0	0	1	1	0	1	0	0	0	4
PA-23-150 Apache	0	3	0	0	0	0	2	0	0	0	1	2	23
PA-23-235 Apache	0	0	0	0	0	0	0	0	0	0	0	0	11
PA-23-250 Aztec	0	5	34	36	33	32	10	31	29	25	10	14	279
PA-24-180 Comanche	12	12	12	11	6	4	4	1	0	0	14	0	81
PA-24-250 Comanche	43	42	23	23	27	11	14	12	3	20	30	27	282
PA-25-150 Pawnee	17	10	11	4	2	13	4	2	0	3	3	1	73
PA-25-235 Pawnee	0	0	0	32	52	30	39	22	10	10	12	0	224
PA-28-150 Cherokee	10	10	0	10	10	13	3	4	7	3	3	1	85
PA-28-150 Cherokee	20	20	66	44	40	38	26	27	20	0	3	7	410
PA-28-180 Cherokee	0	0	0	0	0	0	0	0	00	26	48	20	101
	$2 853	$2 504	$3 988	$3 397	$3 290	$2 701	$1 974	$2 289	$2 180	$2 534	$2 840	$2 156	$32 943
Totals (Aircraft	586	578	849	587	801	556	452	436	441	578	527	439	6 890
Totals (Net Billings)	$10 879	$12 305	$13 306	$11 492	$12 444	$11 707	$8 985	$9 314	$9 849	$12 903	$10 448	$12 662	$130 935

N.R. No Report.

is believed to be working on a high-performance model of its Mark 20C.

Major performance breakthrough with this class airplane is likely to come with availability of lightweight, lower-cost pressurization equipment, although this step may be preceded by introduction of higher power supercharged engines. Such equipment is being eagerly awaited and it will provide a major market potential for those companies who successfully solve technical and economic problems that prevent exploitation of this next technological step in product development.

In the domestic turbine powered field, Aero Commander has a substantial lead with its new twin General Electric CJ610 powered Jet Commander, whose flight test program appears to be off to a good start and is progressing ahead of schedule. With 18 production line positions reserved with firm deposits prior to first flight, the company is expecting a build-up in contracts now that it has hardware flying.

Less certain of firm scheduling now is the Beech Model 120 twin turboprop. It appears now that this project has cooled somewhat in management's eyes. Beech executive vice president Frank Hedrick said that the Model 120 definitely has not been cancelled. Reasons for the decision to keep the program in abeyance for the time being may be that Beech would prefer to have U.S. turboprop powerplants on the Model 120 to make the airplane more attractive to military as well as civil markets. Now the company can mark time on this basis without seriously compromising the basic airplane.

Beech is confronted with several military contract opportunities that appear to have a higher technical and management priority than the 120 because they promise a more immediate and bigger pay-off. Because they are areas for business aircraft in particular and probably will be both competitive, Beech feels its time and funds can be better devoted to these new programs.

There are a half-dozen military requirements pending for a variety of off-the-shelf light aircraft that indicate markets for hundreds of airplanes. These include:

- Light single-engine airplane for instrument training by the U.S. Army and for the Military Assistance Program (MAP).
- Light-twin airplane for instrument training by the U.S. Army.
- Medium-heavy twin airplane for instrument training for the U.S. Navy. USAF also is considering use of this class airplane for utility and personnel transport duties.

Military Assistance Program also has a need for both a light single-engine airplane for primary training, having a fully aerobatic capability, and a medium-heavy twin for use by U.S. overseas missions.

In addition, there is a requirement for a new counter-insurgency (COIN) tactical airplane, which the business aircraft airframe builders feel has definite potential for them.

Export business continues at high dollar volumes, and U.S. business aircraft manufacturers delivered 1,462 export units last year. Though down from 1961's export of 1,581 units, last year's dollar volume totaled $31,293,000 ahead of the previous year's $29,530,659. The increase in dollars is due to the fact that there was a rise in multi-engine equipment.

Beech, Cessna and Piper are moving to consolidate further their gains abroad by building direct company representation, particularly in Europe.

Beech established Beechcraft A.G. in Switzerland. Initially, this operation assisted European distributors in providing new airplanes for demonstrator use, but its primary future function will be to expedite sales in dollar-short countries by exchanging their currency for Swiss francs and in turn exchanging these for U.S. dollars.

Cessna also opened a Swiss branch, primarily to be a source of demonstrators, accessories and parts for its European dealers. Cessna also concluded arrangements with Reims Aviation, of which it owns 49%, to begin assembly of Cessna 172s in France this spring. This initial step will be followed by airframe manufacture.

Piper opened a distribution center in Switzerland that sells wholesale to its dealers in Europe and North Africa.

BEECH QUEEN AIR 80, latest in the Queen Air series, is a 7-9 place airplane having a 1,330-mi. range with reserves.

DE HAVILLAND DH-125 is on order by the Royal Air Force, giving the company a competitive advantage in the executive jet field. Aircraft is powered by two rear-mounted Bristol-Siddeley Viper 20 turbojet engines.

Europe Steps Up Small Jet Competition

London—Manufacturers of European executive and business aircraft, increasingly conscious of the potential world market in small jets, are moving ahead with designs but, in most cases, are dependent on government support to get the projects off the ground.

While the philosophy behind the use of executive aircraft is slowly beginning to make an impact in Britain and on the Continent, the private plane is still regarded primarily as an instrument of national prestige and sport.

Consequently, aircraft to compete with the latest U.S. designs begin to roll out in increasing volume. The European manufacturers are turning to the export market with greater urgency, establishing dealerships and service organizations largely along American lines.

Prime example is the activity surrounding the de Havilland DH-125 executive jet, which holds a long lead in that three airplanes are flying in the test program, one in development of the Bristol Siddeley Viper powerplant alone.

De Havilland undertook design of the small jet on a company-funded basis and later decided to gamble on production of 30 airplanes. Last September the Royal Air Force decided it needed the airplane for training and transport and ordered 22, thus ensuring the company a strong financial line against future commitments.

The company's goal is to sell at least 100 DH-125s, many of them in the U.S. where de Havilland is negotiating for dealerships. Prime customer could be Pan American World Airways, which is interested in 40 airplanes for lease with crews to companies either in the U.S. or abroad. Long negotiations with Beech Aircraft apparently have bogged down and are not likely to be resumed.

De Havilland, with other European manufacturers, hopes to take over a significant share of America's export market. U.S. firms last year exported 2,500 aircraft abroad, against 2,600 the year before, at a value of $29 million.

As another factor, European manufacturers look upon the recent 20% reduction in U.S. tariffs on aircraft to a new 11% ad valorem low as a potential boom to export sales to the U.S. Common import taxes in the Common Market area may show U.S. aircraft sales there.

Proposed Common Market tariffs scheduled to become effective Jan. 1, 1967, include a 15% tax on medium size aircraft, 14% on larger models, and 18% on all gliders. Imported avionic equipment also would be subject to an 18% tariff.

Factors hampering the growth of business flying in Europe include, apart from the cost of today's high performance aircraft, government resistance to promoting the use of aircraft—unless kept to airline standards—largely due to congestion of traffic lines.

Britain has the most serious problem in this area. Neil Marten, Parliamentary Secretary to the Minister of Aviation, said the heyday of private flying in Britain is over because of the vast growth of airline traffic.

The move in Britain toward increased use of business aircraft has been a relaxing of rules at London (Heathrow) Airport, to allow business aircraft landing privileges, but only if the airplane has complete airline standard communications equipment. This rules out all but the most lavishly equipped planes.

Thus, London does not have an airport which could compare even remotely with Teterboro, N.J., despite efforts of business flying enthusiasts to interest the government in such a facility. Closest thing to it is Kidlington Airport near Oxford, where the nearest company is British Executive Air Services, in associate of Beagle which will build the Brantly B-2 helicopter in the UK under license. The airport itself is leased and operated by Pressed Steel Co., Ltd., parent firm of Beagle.

Future of Beagle—builders of the Beagle 206 Twin, the Airedale and Terrier single engine planes, and the Miles 218 plastic twin—appears to hinge a great deal on a possible RAF order for the 206. RAF requirement exists to replace the Avro Anson, in service for 28 years.

In the two years since Beagle first produced the 206, only two have been sold, both to the Ministry of Aviation for service evaluation. Beagle last year planned to build 60 Airedales and completed about 20, of which 12 have either been sold or fed into the dealer pipeline abroad. This includes West Germany, Switzerland, Scandinavia, Australia and Pakistan. At present, company is concentrating on a weight reduction program.

The best seller in the Beagle line probably will be the Miles 218, which makes extensive use of plastic structure. One 218 is flying in a certification program and another should be rolled out before the Paris Air Show June 7-16.

Beagle also is considering development of the Martlet, a small aerobatic plane powered by a 100 hp. engine and featuring a retractable landing gear.

Another airplane with a potentially good international sale is the Short Skyvan, a rugged small transport built by Short Bros. & Harland in Belfast. The airplane now is flying its initial tests and considerable interest has been shown by operators who must work out of rough country. First airplane is powered by Continental engines but later aircraft will be powered by the Turbomeca Astazou turboprop engine.

As an example of utilization of business and private aircraft in Britain, the Air Registration Board lists 504 certified for this use, and another 364 for club and training flying, many of these of foreign make.

Czechoslovakia is trying to expand sale of its lightplane line to the West and may offer major competition to European manufacturers. Omnipol, the state export organization, is quietly exploring the possibilities of expanding dealerships in the West to push sales of its Morava 200D Twin and Trener Master trainer.

Czechoslovakia also has developed a light two-seat jet trainer, designated the L129, but there are no immediate plans to enter the private jet field.

West German's Hamburger Flugzeugbau is investing company funds to develop and produce three prototypes of its 6-10 place HFB-320 model, but it hopes for a substantial government contract to nullify these losses and assure an over-all profit for the project.

Negotiations with the West German air force, which would use the aircraft primarily as a navigation trainer and transport, are now under way, although no order has yet been signed.

Distinguished primarily by a 15 deg. forward wing sweep and a high T-tail, the HFB-320 will be powered by two aft-mounted General Electric CJ610-1 turbojets of 2,850 lb. thrust each. Maximum design cruise speed is 481 mph. Range with fuel reserves has been placed at 1,315 mi.

Thus far, Hamburger has held to its schedule for prototype production, and first flight is still planned for December.

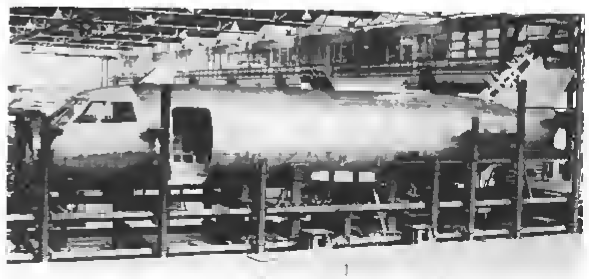
Firm commercial price probably won't be set until government negotiations are concluded. It is expected, however, to run between $620,000 and $750,000, depending on the instrumentation and interior requirements.

France's Dassault, which probably will be the first European firm to roll out a twin-jet executive in the multi-passenger field, also foresees sufficient government orders to permit a commercial sales price below that of the prime competitors facing its 8-12 place Mystere 20.

The French air force, however, is

POTEZ-HEINKEL CM. 191 (top photo) and Piaggio-Douglas PD-808 (below) are German and Italian entries in the light jet market.

SHORT SKYVAN, transport with 3,000-lb. payload, made first flight recently.



DASSAULT-SUD MYSTERE 20, executive twin jet, is shown nearing final prototype assembly. Production models will be ready by 1965.

withholding decision on quantity until after initial flight tests have confirmed the aircraft's performance parameters. Wings and tail unit for the first prototype were recently delivered by Sud Aviation to Dassault's Bordeaux facility for mating with the airframe. First flight is scheduled for May, with the aircraft to appear in the static and flight displays almost immediately afterward at the French air show.

Powered by two Pratt & Whitney JT12A-8 turbojets of 3,300 lb thrust each, the aircraft has a maximum design cruise speed of 513 mph and a maximum range with auxiliary wingtip tanks of 1,550 mi.

In Italy, Piaggio also has been striving to get the first prototype of its PD-808 Vespajet—developed with Douglas Aircraft—in flying condition for the Paris air show. Work, however, has been hampered since last fall by strikes at Piaggio and supplier plants. First flight date is described as "indefinite."

Components for a second prototype also are being fabricated, and both models will be equipped with two Bristol Siddeley Viper 525 powerplants of 3,000 lb thrust each, although aircraft sold in the U.S. by Douglas will be powered by the General Electric CJ-610-1 engine. Maximum cruise speed for the 6-10 place PD-808 is given as 522 mph., and maximum range without fuel reserves is reported as 1,540 mi.

Piaggio, which hopes for government orders but plans to go into production with or without them, has not yet set a price on the aircraft. It is working with Douglas to establish a single worldwide price scale.

Still another twin-jet executive aircraft, the Aermacchi MB-330, is on the design boards. Macchi is negotiating with the Italian air force for a contract and says it can go into production if it receives a government order for a minimum of five aircraft.

Macchi says it can have a prototype flying within a year of the date a go-ahead is received since a large number of components for the six-place MB-330 would be taken from the already proven MB-326 jet trainer. Customer deliveries it says, could begin in 20 months.

Estimated commercial sales price with standard instrumentation, but without navigation radar, would be $320,000. The MB-330 would be powered by two 2,632 lb thrust versions of the Turbomeca Aubisque. Design maximum cruise speed is 435 mph. Maximum range with reserves is 1,234 mi.

If the aircraft does go into production, Macchi in its export efforts will rely heavily upon experience now being gained with the Aermacchi-Lockheed 60 utility aircraft. Sales and servicing organizations for the plane already have been established in Africa, with Lockheed handling the U.S., and Macchi looking for a South American outlet.

Approximately 100 orders for the aircraft have been received, about 50% from Africa, a continent which the European industry regards as a potentially rich market. Five orders have come from South America, and Macchi hopes to boost this substantially once a dealership organization is established.

Present production rate for the aircraft is five to six units a month.

Switzerland's Pilatus Flugzeugwerke also is doing well in the utility aircraft export field. Piston-engine versions of its Pilatus Porter have been sold in North and South America, Africa, Asia and the Far East. Turboprop version powered by a 562 shp. Turbomeca Astazou has been ordered by firms in Alaska, France and Italy.

In the smaller executive jet field, Sweden's Svenska Aeroplan appears to hold a lead among the newer model entries with its SAAB 105. The aircraft was designed essentially as a two-place trainer, and SAAB has assurances that the Swedish air force will order a minimum of 130 if it meets its specifications.

It also is being offered as a four-place executive aircraft, and quantity government orders could permit a severely competitive commercial sales price. Present sales price is $120,000.

Two prototypes are now under construction on production tooling, with a first flight date set for early July. The aircraft has two Turbomeca Aubisque engines of 1,540 lb thrust each.

Establishments Henry Potez of France also plans to continue development of the six-place Mk 3 version of the Paris series of executive jets begun by Morane-Saulnier in 1954.

Potez acquired rights to the Paris early this year when it took over Morane Saulnier, which went into bankruptcy despite some success of the four-place Paris-1 and 2 and the unqualified success of the Rallye and Super Rallye sports aircraft in both domestic and export markets.

Potez also will continue the Rallye production lines and market the two planes under the Morane-Saulnier name. Future of the Potez-Heinkel CM-191 four-place jet still appears to hinge on government orders both in West Germany and in France although development test flying is now well advanced.

In the turboprop field, Potez 8-14 place Potez 840 executive aircraft and potential feederliner remains Europe's strongest contender. Second prototype of the Potez 840, powered by four 530 shp. Turbomeca Astazou-2 engines has been in North America on a sales tour since September with a projected U.S. sales price of $500,000. Third prototype will be rolled out soon.

British Hawker P.1127 VTOL fighter prototype churns standing water on runway to spray as it demonstrates vertical lift capability of its vectored-thrust Bristol Siddeley Pegasus turbojet engine.

International

AVRO BLUE STEEL air-to-surface missile, now operational with Royal Air Force, is transported to V-bomber hardstand on mobile loader.

British Seek to Hold Technological Base

By Herbert J. Coleman

London—Britain's aviation industry, fighting to retain its broad base of technology in the face of tougher competition from abroad, is pressing the government for more financial encouragement in new aircraft and weapon design while simultaneously extending itself farther into cooperative European and U.S. efforts.

Despite the promising future of Britain's development of a vertical takeoff and landing aircraft, and its decision to go ahead with France in the Concorde supersonic transport project, the industry today is faced with manpower cutbacks due to project cancellations and lack of new designs.

Abrupt change in British defense posture, when the U.S. decided to drop the Skybolt air-to-surface missile with little warning to its allies, did not help in clearing the air for the aviation industry here. Instead, the Royal Navy's role will grow when Britain's Polaris submarines go into service, and the Royal Air Force for the first time will play a secondary, support role.

Production is still under way for the Mk 2 versions of the V-bomber force, carrying the Blue Steel standoff bomb, which has a 200-mi. range. A follow-on Blue Steel, with an 800 mi. range, appears to have been dropped in favor of a cheaper weapon that also can be used on the TSR 2 tactical strike reconnaissance airplane, due to fly next December or January.

Some sources say that the TSR 2 was designed without much emphasis on weapons because of the program for extending the life of the V-bomber force with Skybolt. As a result, they say, drastic reappraisal is now under way.

The Polaris program, based on five or six submarines, will cost $840 million, of which two thirds will be spent in Britain. The submarine will use the U.S. launch tube and fire control system, with Polaris A3 as the weapon. Hull design will be based on technology now well advanced in construction of the British Valiant nuclear submarine. Target date for operational service is 1968-69.

Since Polaris A3 missiles will be bought directly from the U.S., the missile sections of the British aviation industry will not share in this development.

Immediate effect of cutbacks, aside from the contraction of the industry's work force, is the loss of design teams. One of every six scientists is reported leaving Britain for a job overseas, primarily to gain better pay and wider latitude in research and development facilities.

Employment in the industry—including electronics and engines—at the end of 1962 totaled 288,400. This was 15,800 fewer than the preceding year.

With the exception of Short Bros. & Harland and Whitworth Gloster, the industry has work in hand to keep these people occupied. But the prevailing feeling within the industry is one of uncertainty for the future, beyond 1965.

A case in point is A. V. Roe, Ltd., builder of the Vulcan V-bomber, Avro 748 turboprop transport and the Blue Steel standoff bomb. The Weapons Division employs 2,000 men who will not be required in 1965 after completion of the Blue Steel contract. Another 6,000 work on the Vulcan production line, but some of these can be transferred to the Avro 748 military version, of which 40 are ordered.

The long-term answer for A. V. Roe seems to be getting a contract to replace the Shackleton maritime reconnaissance aircraft, now being modified to extend its life. Decision on a jet replacement for which Avro has a design in competition with British Aircraft Corp., will be delayed, however, for at least a year.

Even the awarding of a new design contract may not be of immediate help. Whitworth Gloster, for example, is the leading contender for OR-351, a jet-powered V/STOL replacement for Beverley and Hastings transports. But company officials say that even if the contract is awarded now, it will have no effect on the planned layoff of 3,000 employes in July because of approaching phaseout of the Argosy turboprop transport line.

On the other hand, Minister of Avia-

WINGS OF FIRST BAC 111 are mated to the fuselage at British Aircraft Corp Hurn plant.

tion Julian Amery believes industry forecasts of its future are overly pessimistic

Employment has dropped, Amery concedes, but is still higher than it was three years ago

He told AVIATION WEEK & SPACE TECHNOLOGY that government spending will remain high and that he was confident that future prospects of the industry will be good. He added: "The last Farnborough show was a great tonic to us."

Amery answered criticism by underlining Britain's advances in VTOL, as epitomized by the Hawker P.1127, and powerplant work in Bristol Siddeley engines and Rolls Royce. While the outlook in guided missiles is less promising, Amery stressed the importance of the Franco-British agreement to build the Concorde jointly. Britain—despite its Common Market setback—will continue to work closely with European governments and industries, he said.

Amery also is intensely interested, like his predecessor, Peter Thorneycroft, now Minister of Defense, in pushing Britain into the space field.

Work in this area is almost completely confined to the government's own research establishments, primarily at the Royal Aircraft Establishment at Farnborough. Concentration now is on design of a communications satellite that could be launched by the de Havilland Blue Streak using a Saunders-Roe Black Knight as a second stage. Another project, with a lower priority, is design of an orbital space plane using conventional engines for takeoff and a Bristol Siddeley ramjet in orbit.

Britain is still putting money into the Blue Streak program as part of its commitment to the European Launcher Development Organization (ELDO) which, in a large part, was a Thorneycroft concept.

Possibility of the Ministry of Aviation being absorbed into a "Pentagon style" defense establishment is under study by a committee headed by Lord Ismay, but its report has not yet been made. There is considerable government and political pressure toward streamlining the various ministries, downgrading the Imperial General Staff in favor of stronger service secretaries.

Another area of agitation for change is the government levy on sales of any design in which the government has given financial aid.

Last year, for instance, the government advanced about $14 million for the Vickers VC 10 and de Havilland Trident development program. In return, the government shares any profits from future sales under a complex formula that is weighted three to one in favor of the manufacturer on the earlier sales until the estimated amount of its investment has been recovered. Then it shifts to three to one in favor of the Ministry until its investment has been recovered in full, and then in proportionate shares until the Ministry has received 125% of its original investment.

Industry has long attacked the levy as unrealistic and damaging in the face of ever-increasing foreign competition itself often actively subsidized. The government stand is simply that it deserves a return on taxpayers' money.

This levy policy also will prevail, Amery said, in the case of the $28 million the government recently advanced to Short Bros. to complete its contract for the Belfast turboprop freighter and the Seacat missile. Amery does not consider the aid to Short Bros. as a subsidy.

Other government grants, Amery said, have been made for British blind landing developments, the Hawker P.1154 supersonic VTOL program, now in the design study stage, and to Rolls-Royce for development of an advanced Spey engine. Amery left it unsaid but the P.1154 support implies Bristol Siddeley will get considerable government support in developing the BS.100 vectored thrust engine for the airplane. The situation currently is obscure because Rolls-Royce submitted a proposal to re-engine the P.1154 with vectored thrust Speys.

Since the BS.100 is a larger version of the proven Pegasus and was the powerplant around which Sir Sidney Camm of Hawker Aviation designed the P.1154, chances are the nod will go to it. Certain segments of the industry are still resentful that Bristol Siddeley was forced to take U.S. mutual aid funds to develop the Pegasus on a 75-25 basis, thus giving the U.S. a primary claim to the engine technology.

Currently, according to Sir Arnold Hall, former managing director of Bristol Siddeley who became managing director of the Hawker Siddeley Group earlier this month, the BS.100 plenum chamber burning feature alone is being supported by Mutual Aid Funds. Building of a prototype engine will depend on government aid, he added, since Bristol Siddeley feels it cannot handle a program of this magnitude on a private venture basis.

In discussing company research, Sir Arnold said that he is not convinced that technological fallout necessarily comes from huge government investments. A company, he continued, must continue to devote part of its resources toward this end, or accept the fact that its research will be directed by the government or one of its agencies.

He favors joint participation by government and industry, explaining that this is one reason for Britain's engine progress in the supersonic transport field. The Olympus 593 supersonic transport engine is also the engine for the TSR.2 strike reconnaissance fighter.

In an era when Britain's aviation industry is group-conscious, Sir Arnold says he doubts that the country eventually will have a single engine company, formed by a merger between Bristol Siddeley and Rolls-Royce. The engine business now is split between military and civil turbojets with Rolls concentrating mostly on the latter.

The engine picture, while not so bright at Rolls-Royce, shows signs of improving, Sir Denning Pearson, chief executive, said. Rolls has put 16,000 of its Aero Engine Division workers on a shorter work week, in some cases a cut of up to 8 hr. However, the plan was to avoid laying off men and is a temporary measure until production builds up later this year to meet existing orders.

The orders mostly involve production of the Spey and the Conway. 42 Speys will go into the Trident three jet transport, and the Blackburn Buccaneer NK.2 naval strike fighter, and the Conways are earmarked for the Vickers VC.10 series. In addition, the Tyne and Dart turboprops are still in production, with the former getting a boost from the Breguet Atlantic maritime reconnaissance plane orders. The Dart will go into the Japanese YS-11 turboprop transport.

Rolls decided to enter the vectored thrust field using the Spey because the engine was considered proven and was adaptable to the system. The new version makes it simpler for Rolls to compete in Europe, since it now has a license agreement with Mauna, the West German engine company.

Rolls has just about abandoned its efforts in the supersonic transport field, although an engine for this purpose has been designed. All government support in this area is going to the Bristol Siddeley Olympus and any U.S. supersonic transport would be powered by a U.S. engine.

In the pure lift field, Rolls has a heavy stake with its RB.108, the powerplant now in use for flight testing the Dassault Balzac prototype of the Mirage 3V. The latter will use the RB.162. Sir Denning has hopes for success of the Rolls-Continental engine line for business aircraft. Largest order so far has been for the Morane-Saulnier Rallye series.

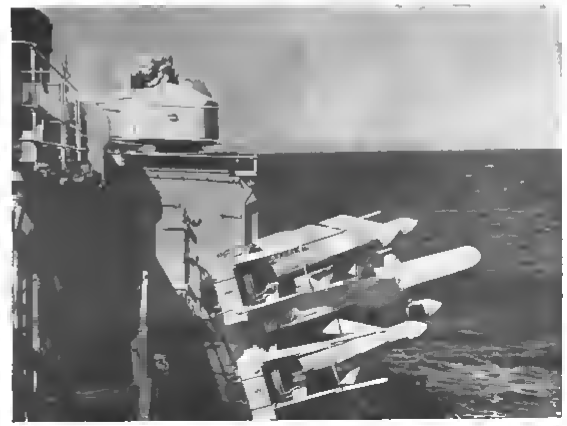
Rolls has a considerable investment in the marine nuclear powerplant field, and Sir Denning said the British Polaris agreement should have considerable effect on this area, primarily in the production of cores.

At British Aircraft Corp. Vickers-Armstrongs, English Electric Aviation, Bristol Aircraft and Hunting Aircraft, emphasis ranges from the Vickers VC.10 and Super VC.10 engine transport family to the de Havilland DH.125 executive jet and the TSR.2 strike-reconnaissance fighter.

The latter airplane probably will be put into extensive production, since the trend is toward an all-purpose airplane for the Royal Air Force when the V bomber force is retired. Originally, the TSR.2 was designed for low level missions, but the specifications now call for high altitude capability also. Because of the ensuing redesign, the program has slipped at least six months. First flight is set for December or January. Crash program is under way to design a new low level weapon for the TSR.2, incorporating a nuclear warhead, probably a comparatively short range air-launched missile boosted by a small jet engine. There also is speculation that the TSR.2 will carry a free-fall bomb which could be launched by a LABS maneuver.

Other BAC missile work centers on advanced versions of the Bloodhound and Thunderbird surface-to-air missiles, and a follow-on missile to replace the de Havilland Red Top heat-seeking air-to-air missile. The Vickers Vigilant is in production for the British Army and has been ordered by Kuwait and Finland. For overseas sales, it is fitted with a Swiss hollow-charge warhead. Another BAC missile is the Fairey Swingfire, which so far has been test fired with hand-made hardware only.

The short haul BAC 111 twin-jet



SHORT SEACAT missile system is shown installed on board HMS Decoy. Launcher is in foreground, visual director in the rear.

transport, now has 35 orders and is showing strong potential in the world air line market The VC 10 is on order by the RAF Transport Command, but the airplane is not expected to approach the sale of the Boeing 707 family of subsonic jets

BAC is running two flight research programs, the Bristol T 188 stainless steel Mach 2-3 testbed, and the Hunting H 126 jet flap aircraft The second T 188 will have higher powered de Havilland Gyron Jr afterburning engines for research into higher supersonic speeds Variable geometry configurations are under investigation by Dr Barnes Wallis of Vickers-Armstrongs, but this is confined to a Ministry of Aviation study contract

Hawker Siddeley Aviation's major problem is large-scale layoffs at Gloster Whitworth, according to J T Lidbury, the group's chief executive, and sales efforts will continue to be stressed on the Argosy turboprop transport

Ten of the transports are being built on speculation

Formation of a strong confederation with companies in France, Italy, Holland, West Germany and Belgium has been carried out by Hawker Siddeley, primarily with large scale production of the Hawker P 1154 in mind should the airplane be selected for NATO forces A recent agreement with Northrop in the U S is aimed at production for the U S Army if a contract is awarded for either the Hawker P 1127 or the P 1154 successor

Lidbury blames the slow start of the Trident, which has 27 orders, on the fact that the airplane was built to British European Airways specifications, rather than for the world market But he said that the Trident 1E and 1F versions will be tailored for other airlines

British R&D Funding

London—Substantial British government funding is going into aerospace research and development work by British companies, not including the money spent on various Royal Aircraft Establishments responsible for airframe, electronics and engine programs

Industry R&D expenditures in 1962-63 totaled $593.4 million, against $73 million spent with the establishments The government also is committed to provide $18 million for the European Launcher Development Organization (ELDO) but the money has not yet been spent since the seven-nation convention has not been signed

In addition the government is spending $1.7 million with the industry and another $20 million with the Australian government on joint development of guided missiles and equipment.

In the missile department, Hawker Siddeley is developing the CF 299 shipborne missile under a development contract with the Royal Navy The weapon will be available for export Modification program for the Hawker Hunter to qualify the airplane as a low level strike fighter is quite large, to the point where the company is even buying back Hunters from Belgium for modification and resale

The company is currently building the Mk 2 version of the Blackburn Buccaneer naval strike fighter, repowered with two Rolls-Royce Spey engines, and a Mk 3 version is expected to follow The Royal Navy is buying the Martin Bullpup air-to-surface missile for the Buccaneer

At Belfast, Short Bros still has only 10 orders for the Belfast turboprop freighter, and the recent Defense White Paper made no provisions for more

Considerable RAF VC 10 work, such as building the loading doors, will go to the company However, Short Bros which virtually pioneered in the British VTOL effort with its SC 1, has been almost ignored in advancing the state of the art according to Hugh Conway, joint managing director One SC 1 is being used for instrumentation development at RAE Boscombe Down and RAE Bedford and the other is being used in work on the VTOL blind landing system at Belfast Both programs are relatively low on the government funding scale

As far as missiles are concerned, Conway considers the Short Seacat a success in view of its foreign sales The Tigercat version for land forces is well advanced, with present work concentrating on the radar section

Conway said the company will continue to push its jet Belfast version and is studying the possibility of building the airplane with an existing wing, such as that used on the Lockheed C-141

British companies outside the groups are Handley Page and Westland Aircraft The former has work for the next three years on the V-bomber program with the Victor and currently is designing a jet version of the Handley Page Herald transport, along with an executive version of the turboprop Herald

All of Westland's work is on construction of military helicopters for the three services, involving in most cases licensed Sikorsky designs There are no plans to build a civil helicopter, though a license agreement will be retained to build the Vertol line if any sales are made in the United Kingdom The company plans to send its Westland SRN 2 Hovercraft to Canada this summer for a series of demonstration trials Construction is well advanced on the larger SRN 3 passenger version

FRENCH TESTBED for a VTOL strike fighter is the Dassault Balzac, a modification of the Mirage 3. Louvers are open as air intakes for Rolls Royce RB 108 lift engines

French Reach for Technology in Nuclear,

By Robert E Farrell

Paris—France during 1962 committed its aerospace industry to a series of highly ambitious civil and military goals which, if achieved, will make France the top air power in Western Europe.

On the civil side, the outstanding event of the year was the signing last November of a Franco-British agreement under which the two nations jointly will build a supersonic transport, informally called the Concorde. The French, a year earlier, had decided independently to push ahead with a Mach 2.2 transport. But the deal with the British government cuts down the financial risk and yet keeps the French industry involved in modern jet transport activities.

On the military side, the French during 1962 committed themselves deeply to independent development of an airborne and seaborne nuclear strike force. Initial airborne elements of this force will become operational late this year. France by rejecting nuclear dependence on any of its western allies is now definitely committed to running the risks—and reaping the possible technical benefits—of being an independent nuclear power.

In addition to these two major civil and military goals, the French aerospace industry still continues to develop and sell a wide range of civil jet and turboprop transports, supersonic military fighters, civil and military helicopters, and specialized missiles. During 1962, France even began adopting U. S. mass production techniques in the lightplane field with the Morane Saulnier Rallye.

French officials are aware that their heady aerospace ambitions involve considerable risk. A technical or marketing failure in the supersonic transport project, for example, would affect about a third of the industry. Mounting, unexpected costs in the nuclear strike force development are cutting into other segments of the defense budget. End of the Algerian war during 1962 helped ease defense cost pressures some, but not enough.

Moreover, government and industry officials are worried about the industry's export future, at least through the middle 1960s. Preliminary figures show foreign orders placed during 1962 dropped sharply to $295 million from the record high of $380 million during 1961. Main cause is a fall in Caravelle sales, though other areas declined as well. This downtrend is expected to continue through 1965.

By then, export business is expected to bounce back as the supersonic transport finds buyers and as several promising French aircraft, currently at the prototype stage, go on the market.

Industry's problem at the moment is to develop intermediate business, either civil or military, to keep its 85,000 workers busy. This may prove difficult and some are predicting the airframe companies, whose workers make up 56% of the industry, may have to lay off 10% of their work force by year end.

Part of this industrial shake out is unavoidable. Electronics, chemicals and shipbuilding are beginning to take more and more French defense money to finance the country's nuclear strike power. Yet most observers, while not ignoring recent warnings, think industry will adjust to its changing situation. In France, airframe companies are relatively stable since they traditionally share production. A company can lose a contract but still take part in the production of its competitor's aircraft.

Finally, while France's aerospace industry has put the nation in a commanding position in Western Europe in size it is about one-third that of Great Britain's, which employs 288,400. France's 85,000 employment level can't decrease much as long as the government maintains its ambitious aerospace projects in the civil and military fields.

France's drive toward an independent nuclear capability is channeled into two major, interrelated developments, both of which recognize the basic need to possess technology:

- **Dassault Mirage 4A supersonic bomber fleet of 50 aircraft.** Though not impressive in number, this force de frappe is programmed to provide a deterrent capable of destroying up to five Russian cities, a high enough price to dissuade Russian leaders from attempting to conquer France, the French hope.
- **Submarine launched ballistic missile.** Projected availability of this weapon system late in the decade is the reason for holding the Mirage 4 fleet to 50 aircraft.

Powered by two Snecma Atar K turbojets with afterburning, the Mirage 4A can exceed Mach 2. Cost of the 50 aircraft is estimated at $200 million and the French expect the entire force to be fully operational by 1965. Four pre-production aircraft were flying until the first prototype was lost in a crash recently.

Certain French air force supporters doubt the late-1960s missile timetable, and are urging expansion of the Mirage program. This schedule calls for:

- **1965-67:** Mirage 4A armed with a free falling 60-kiloton bomb to carry out missions at altitudes beyond the range of known Soviet and U. S. ground-air missiles. Range and state-of-alert during periods of international tension will be improved by French acquisition of 12 Boeing KC-135 jet tankers, initial deliveries of which are slated to begin late this year. U. S. Defense Department, though opposing an independent French nuclear force, approved the sale which fills an essential requirement for an effective nuclear strike force.
- **1967-69:** Mirage 4A armed with an air-to-ground missile designated AS-2. Again, the Mirage would run to the target region at high altitude, releasing the AS-2 from a stand-off position of 300 mi. Probably powered by a solid-fueled rocket engine, the AS-2 would reach Mach 5 at the end of its engine burnout.
- **1970-72:** Mirage 4-106, unofficially called Minerva, and also armed with the AS-2. The 50,000 lb Mirage 4A would be scaled up to roughly twice that weight and equipped with two Pratt & Whitney JTF10 turbofan engines. Snecma is developing an afterburner to increase the U. S. engine's takeoff thrust from 10,000 lb to 18,000 lb.

Development of the final stage is based on the premise that by the early 1970s ground-to-air missiles probably will have been developed to point where even supersonic high altitude aircraft missions will be ruled out. By equipping the Mirage 4 with more powerful engines, as well as using steel and titanium in its construction, the resulting Minerva combination will make low level penetrations at Mach 1.6 and the AS-2—armed with a thermonuclear warhead—will be fired at the target from stand-off position.

This program hasn't yet been approved by French Defense Ministry which so far does not accept the doubts of those who say the development by France of a Polaris-type weapon system will take longer than is presently believed.

France isn't basing its aircraft nuclear strike capability only on the Mirage bomber. Dassault's Mirage 3 French air force fighter, initial squadrons of which are now fully-operational, and the Dassault Etendard 4M shipboard fighter, are being equipped for nuclear missions. Of several hundred Mirage 3s ordered, probably about 150 are earmarked for nuclear missions. Forty of the French navy's 90 Etendard fighters, currently being delivered, will have similar capability.

Even Dassault's Mirage 3 VTOL version will have nuclear capability. The Mirage 3V, whose first flight is planned this year, will be conventionally powered by a Snecma-modified JTF10 turbofan engine. VTOL power will be eight Rolls-Royce RB.162 liftjets. A smaller prototype version of the Mirage 3, called the Balzac, flew in 1962 and completed initial hovering and low-speed maneuvering tests successfully. French hope to get German orders as well as their own for the Mirage 3V.

Initial funds are in the military budget this year for the first nuclear, missile-firing submarine, which is scheduled to be launched in 1968. The French hope to have three such submarines by 1972 and claim to be encouraged by their ballistic missile tests.

In addition to strategic missile work, the French continue to develop their air-to-air Matra 530 missile under a new designation of 540. The Matra 530, which equips the Mirage 3 fighter, is described by French officials as the only missile of its type in the Western world that has been fired from aircraft flying at speeds above Mach 2.

Nord Aviation's ground-to-air missile, the AS-30, is now in full production, and so is the company's CT-41 Mach 2 target missile. Nord Aviation says it has now produced about 100,000 production line missiles, mostly the wire guided SS-10, SS-11, SS-12 and Entac tactical missiles.

Space efforts remain fairly modest, although still the most ambitious in Eu-

FOURTH PREPRODUCTION Dassault Mirage 4A strategic bomber has the production configuration in all external aspects. Housing at base of fin is for drag parachute. Powerplants are two Snecma Atar K turbojets with afterburning

Mach 2 Transport Programs

SUD AVIATION has begun flight testing of a triple-turbine heavy helicopter, the Super Frelon

rope. France's 1963 budget contains 5900 million for research and development, of which only 532 million is allocated for space research. This figure compares with 817 million spent on space research in 1962. Of the 532 million about 513 million will be used to finance French participation in European-wide space projects and 512 million for French and NASA programs. Development of the French Diamant booster, which is scheduled to orbit the first French satellite in 1965, has been allocated 54.2 million.

The Diamant program is being watched closely for it will indicate whether the French can meet their Polaris-type missile development schedule. If France does launch its civil Diamant satellite by 1965, there is a good chance it will do as well in its late-1960s military missile schedule.

Diamant will be a three stage booster, and the first stage—called Topaze—was successfully tested in December. The other two stages—called Emeraude and Saphir—will be tested this year. Diamant will weigh 37,500 lb. and will put a 175 lb. payload into orbit with a perigee of 185 mi. First launching in 1965 will be made from the new civil space launching center to be built in southwestern France on the Mediterranean coast.

Biggest French civil aviation effort, the Anglo-French supersonic transport, stems from a medium range supersonic transport project—the Super Caravelle—which would have had a limited market and would have been entirely financed by the French government. By joining with the British, the French not only cut down the financial risks but at the same time increased the sales prospects.

On the French side are two airframe companies, Sud Aviation and Avions Dassault, and the state-owned engine company, Sneema. France will build one medium-range prototype and one pre-production Concorde. The British will build a North Atlantic version in both prototype and pre-production aircraft. The French-built Concorde will gross about 200,000 lb., the British 250,000 lb. Each version will be powered by Bristol Siddeley Olympus 593 turbojet engines.

Sud officials say first flight of their prototype may take place late in 1966. First pre-production aircraft will fly a year later and production planes are to begin rolling out at the end of 1968. This schedule will permit airline service by 1970.

French industry observers have some reservations about the Concorde, although in France, unlike in Great Britain, there has been practically no public debate on the project. These reservations don't deal so much with the $500 million which will be spent over the next eight years as they do with the economic and management aspects of the program.

Sud officials remain confident that the Concorde will prove to be as economic an aircraft as preliminary studies indicate. This spring, in fact, French and British expect to begin their marketing effort.

Yet Air France and BOAC, the two carriers which have to be sold first, are far from convinced by preliminary operating costs. There also remains the unanswered question of how future U.S. supersonic transport plans will affect Concorde sales.

A committee of French and British officials will supervise two Franco-British steering groups, one for airframe and one for engines. Top posts on the airframe and engine committees will rotate between the two nationalities every two years.

This rotation principle bothers those who feel the project needs management stability. Georges Hereil, former Sud Aviation president, quit last summer over the two-year rotation issue. Hereil felt the project wouldn't be properly managed unless top jobs were held for at least five years, but was not supported by the French government. Gen. Andre Puget, succeeded him as Sud's president and managing director and also as president of the Concorde airframe group until 1965.

Despite denials, a question remains whether France's blackball of Britain's bid to enter the six-nation Common Market may not eventually plague the Concorde program. Much of course, depends on how the Franco-British political split works out this year. Majority feeling in French industry is that both countries are "condemned" to cooperate in the supersonic transport field.

Sud Aviation, in addition to its growing involvement in the Concorde program, continues to develop its Caravelle transport. Twenty-nine orders placed during 1962 brought Caravelle sales to 166 aircraft. Sud officials, incidentally, now use a figure of 150 aircraft as the Caravelle breakeven point, instead of the 225 aircraft previously used.

Biggest Caravelle sales success during the year was Finnair's order for six Caravelle Super B models. It was Sud's first order for Caravelles equipped with U.S. engines, in this case the Pratt & Whitney JT8D-1 turbofan. Sud also is offering a Super A model powered by General Electric CJ805-23C aft-fan engines.

Military Missions Begin Study of India's Air Defense Requirements

New Delhi—India, jolted from its belief that an open military threat from neighboring Communist China lay perhaps 20 years away, is striving to piece together an effective defense force plus the broad industrial base needed to support it.

Neither will be easy. Substantial U.S. aid is likely to be required for both. American aerospace companies undoubtedly will be called upon to participate, either within the framework of formal U.S. aid programs or through contracts negotiated directly with India. To what degree is an unanswered question since a comprehensive program agreed upon by all sides has yet to be evolved.

Following a professed neutralist policy and a limited purchasing program geared to the same concept, India has accumulated an assortment of equipment accompanied by all the logistics and support headaches this implies. The air force alone is operating 21 different types of aircraft and helicopters, including hardware from Great Britain, the Soviet Union, the U.S. and France.

Standardization, East or West, will be difficult if not impossible, since India still hopes to keep open its economic channels to the Soviet Union and other East European nations despite a definite shift towards the West—politically, emotionally and militarily—as a result of the Oct. 20 Chinese assault against the country's border areas in the Himalaya Mountains. Aside from the problems of logistics and support, such a variety of equipment also cramps attempts to meld an integrated force.

Military missions from the U.S., Great Britain, Canada and Australia, as an example, are currently studying India's air defense needs. A major one is establishment of a radar warning network. But American authorities are asking how this can be accomplished without security problems when India's first-line interceptor may become the Soviet MiG-21 supported by on-site Russian technicians and instructors. There is no indication the Russians themselves will supply such control capability.

In the fighting last fall, before China called, and India tacitly agreed to, a unilateral cease fire, both sides scrupulously avoided the use of tactical air.

For China and its limited goals, it was not needed. India, for its part, had no desire to touch off an aerial conflict in which China could justify use of its Soviet-made Il-28 medium-range jet bombers against the vulnerable cities strewn across the Ganges delta region. Warning times would be minimal, and despite the difficulties involved, China probably could escort its bomber force with MiG-17 and MiG-19 fighters from Tibetan bases to offset the effectiveness of India's Hawker Hunter and Folland Gnat defense force.

Besides its failure to use airlift as the primary source of supply for its meagerly equipped front-line troops, India avoided committing combat aircraft to the point where reconnaissance flights over Chinese-held Indian territory were flatly banned. As a result, Chinese troops, sheltered by the mountainous terrain, could mass and attack without detection.

Rapid build up of a broad industrial base also will be difficult. India inherited more than 20 ordnance factories from the British at the time of independence, including a modern aircraft production facility, and by late last year approximately 50,000 persons were listed as employed in the various defense firms.

Much of their effort, however, went into products far removed from defense. Items rolling off the assembly lines included such diverse products as pressure cookers, three-wheeled automobiles, leather goods, film projectors and double barrel shotguns.

Despite some progress, the defense industry as now envisioned will be largely a matter of creation rather than conversion.

Requests for U.S. aid that began rolling in almost at the moment of the Chinese attack are now being reviewed in perspective of the cease fire, and efforts are being made to establish priority of need against what the U.S. can and will provide.

The Western air defense missions, for instance, are delving into India's overall requirements for aircraft, rockets and ground-to-air missile systems as well as radar.

Recommendations will be made to the Indian government, and some U.S. aid probably will be forthcoming. To a greater degree, however, the U.S. will expect India to purchase directly or negotiate licensed-production agreements. In addition, tight State and Defense Department security restrictions can place U.S. industry bidders at a disadvantage in areas where British and French companies can compete.

Thus year should tell how successful Sud's advanced Caravelle sales campaign will be. Sud officials haven't yet given up on the U.S. market.

Moreover, trade-in of earlier Caravelles in orders for the Caravelle Super, as Sud arranged for Finnair, may help. Sud expects availability of an automatic landing system for the Caravelle cutting landing minimums to 100 ft. ceilings and ¼ mi. visibility, to assure continued airline interest.

This year will determine the fate of at least three promising French civil transports: the Potez 840 four-engine turboprop, Nord Aviation's Super Broussard's twin-turboprop, and Breguet's STOL 941 four-engine turboprop.

Developed as a private venture by Henry Potez, the 840 is powered by four Turbomeca Astazou engines, each developing 560 shp. Initial prototype of the 18,700-lb. 24 passenger business feeder aircraft flew in April, and the second prototype early in 1962. Second prototype is fitted with weather radar and a modified cockpit. Turbo-Flight Inc. of Chicago, owner of the 02 prototype, has shown the aircraft throughout the U.S. on a demonstration tour. Standard price in U.S. runs about $500,000.

Production plans are divided between the company's French factory and a new factory near Dublin, Ireland. Though no production orders had been announced by mid-February, Potez planned to turn out its first production model in France in the first quarter of 1964 and an initial production model in the Irish factory late that year.

French government money has been involved in the development of Nord Aviation's 260 and 262 Super Broussard project, a high-wing feeder aircraft powered by two Turbomeca Bastan 4 turboprops each developing 1,000 shp. and designed to carry 26-29 passengers over 500 mi. stage lengths.

Nord Aviation flew the first 260 production version early in 1962 and the pressurized version—the 262—last December. A pre-production order of 10 aircraft is largely completed and will be used to accelerate certification testing. By 1964, Nord expects to be turning out two aircraft monthly. A U.S. demonstration tour is planned next fall.

This year will also be crucial for Breguet's 941 STOL aircraft. Powered by four Turbomeca Turmo 3D turboprops each developing 1,200 shp., the 941 has a gross weight of 40,000 lb. The aircraft uses the deflected slipstream, or blown-wing principle, for STOL performance.

The 941 prototype recently completed its test program at the government flight test center at Istres and now has logged about 250 hr. with 500 landings.

with products having a roughly similar capability.

The U S. India planners contend, has denied or ignored their requests for information on the Sidewinder and Hughes Falcon air-to-air missiles. Britain, on the other hand, has answered similar requests for data concerning the de Havilland Firestreak and Red Top infrared systems, and the French have supplied details concerning several airborne missiles as well as anti-tank weapons.

The U. S. and United Kingdom together have agreed to supply India with $100-120 million in equipment and supplies to compensate for losses sustained in the border fighting last October and November. Beyond this, Britain may be willing to go farther than the U. S. in supplying off-the-shelf equipment on an aid basis since India also is a leading member of the Commonwealth.

For the present, however, Britain lacks a modern aircraft with minimum-weather close support capabilities, and India has requested information on the McDonnell F-4B and the Northrop F-5A. If these are unavailable under any aid program, India may be willing to purchase one of the two outright or to negotiate a licensed-production agreement, since New Delhi officials concerned with the problem say the MiG-21 aircraft has little or no such capability.

Probable total number of MiGs will be marginal in any event. Under present agreements, the Soviets will supply at least 12 and possibly as many as 24 of the aircraft directly from Russian production sources—specimen copies for pilot training. In addition, it will build a MiG-21 airframe and engine manufacturing facility at Orissa on India's East coast where another 40 aircraft are scheduled to be built.

After a series of delays and Western doubts as to whether Russia would meet its commitments and risk a wider schism with its recalcitrant Chinese ally, an initial increment of four MiG-21s arrived in India early this year. Just when the others will be delivered and, more importantly, when Russian technicians will begin construction of the Orissa facility are still debated.

Twelve Lockheed C-130 turboprop transports sent to India last November are still there and flying with their American crews on a daily basis. More U. S. aid probably will be provided in the form of high-payload helicopters capable of operating at altitudes of over 20,000 ft. from air strips located at elevations of up to 17,000 ft. above sea level.

A quantity of C-130s also may be offered to India on a permanent basis. While impressed by the performance of the U. S. Air Force C-130s flying from New Delhi's Palam Airport, Indians are concerned over its high operational costs.

Two de Havilland DHC-4 Caribous, made available when the U. S. Army surrendered its production line rights to them, currently are being evaluated in India in a related move in hopes of improving the air force's airlift potential.

Indian Air Force officials plan to evaluate the aircraft for high-altitude operations with several turboprop powerplant configurations, including a General Electric T64 installation and the Rolls-Royce Dart. If the aircraft proves successful, the government is expected to negotiate a licensed production contract for manufacture of the Caribou using, if possible, the Dart engines since they already are being produced in India for the Avro 748 series under construction at Kanpur.

Final decision on this and other defense requirements may require time—assuming there is no new eruption along the border. One U. S. official recently said:

"The Indians have had to take on rather substantial problems in the last few weeks, possibly as many as in the 15 years since independence."

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CANADIAN AIR FORCE CF-104D trainers are lined up on the ramp at RCAF's Cold Lake, Alberta, station where Canadian pilots undergo transitional training prior to assignment in Europe with Canada's NATO strike-reconnaissance squadrons.

Canadian Defense Policy Shift Looms

By Donald E. Fink

Ottawa—Growing Canadian awareness of the gap left in the North American air defense system by the ousted Conservative government's refusal to accept nuclear warheads is forging a shift in Canadian defense policy.

An $86 million austerity cut, which reduced the 1963 Canadian defense budget to a little over $1.6 billion, made Prime Minister John G. Diefenbaker's vacillating non-nuclear defense policy even less popular with the military forces and the aerospace industry. As a result, Canada's current political campaign has brought pressure on the four Canadian parties, including Diefenbaker's Conservatives, to define their defense policies unequivocally.

Public sentiment, reflected by editorial comment and public opinion polls, strongly favors acceptance of nuclear warheads in accordance with commitments Canada made in North American Air Defense (NORAD) and North Atlantic Treaty Organization (NATO) agreements.

U.S.-Canadian relationships on the nuclear arms question were a contributing factor in the downfall of the Conservative government. During a Liberal-sponsored debate in Parliament on defense policy, Diefenbaker said acceptance of nuclear armament still was under negotiation between the U.S. and Canada. The U.S. State Department replied with a statement chiding Canada for failing to make any positive nuclear proposals and refuting Diefenbaker's contention that nuclear defensive weapons were of questionable value in Canada.

Despite his charge of American interference, Diefenbaker failed to survive a no-confidence resolution in the political uproar that followed.

Reversal of Canada's non-nuclear defense policy will mean arming Canada's Bomarc B anti-aircraft missiles and re-equipping its five squadrons of CF-101B jet interceptors, the latter with Douglas MB-1 Genie nuclear air-to-air missiles.

Bomarcs were purchased from the U.S. in 1958 after cancellation of the Avro CF-105 Arrow jet interceptor program left Canada without a weapons system to meet its NORAD obligations. They are in place at sites near North Bay, Ont., and La Macaza, Que., but are standing useless on their launch pads pending a decision to arm them. Bomarc B is not designed to use conventional warheads.

The CF-101s, which had been in use by the U.S. Air Defense Command with Genie, had to be re-equipped with Hughes Falcon 2 conventional warhead missiles before delivery to the Canadian NORAD units. The CF-101s were obtained by Canada in a three-cornered exchange under which Canada assumed control of 11 additional Pine Tree radar stations formerly supported by the U.S. and which also included an F-104C production program in Canada.

Reversal of the nuclear policy also will mean the arming of the Royal Canadian Air Force's eight CF-104G strike-reconnaissance squadrons scheduled for complete deployment in Europe by the end of the year. Canada agreed to replace its obsolescent CF-86 and CF-100 squadrons with nuclear strike-reconnaissance squadrons when NATO changed its air strike concept in 1959.

Lockheed's F-104G was chosen to equip them. Canadair, Ltd., of Montreal, awarded the contract to build the 200 aircraft required, now is nearing the end of that production order. Orenda Engines, Ltd., Toronto, is building the General Electric J79 engines.

First CF-104G squadron is at its station at Zweibrucken, Germany, but will not become operational until it receives nuclear weapons. Formation of the second squadron is under way at Baden-Soellingen, Germany.

Anti-nuclear feeling, based primarily on "ban-the-bomb" sentiment, once was strong in Canada, but public understanding of the need for nuclear weapons in defense has increased. Canadians also are becoming more aware of the extent of Canada's involvement in NORAD, which has Canadian Air Marshal C. Roy Slemon as its deputy commander. The fact that NORAD annually channels about $250 million worth of business to Canada's aviation industry also is becoming more widely appreciated.

Canadian military forces continued to modernize during 1962, despite the continuing nuclear controversy and the austerity cut. Current Royal Canadian Air Force programs are not affected by the cut, but Army and Navy efforts to expand their aviation and missile programs face obstacles.

RCAF modernization programs which were started in 1962 and which will continue through 1963 include the following:

- **Construction** of seven new heavy radar stations which are being built to augment Pine Tree Line 2 and which will extend Canadian radar coverage farther north. Two are completed and the remaining five are scheduled for completion by the end of 1963. These will become part of the network controlled by the underground, hardened SACE (semi-automatic ground environment) center now nearing completion at North Bay, Ont.
- **Re-equipment** of the RCAF Air Transport Command fleet with C-130B Hercules transports, CC-106 Yukons, military versions of the CL-44 without the swing-tail, twin-engined CC-190 Cosmopolitans. Canadair's turboprop versions of the Convair 440 which replace the Dakota (C-47), and Grumman SA-16 Albatross flying boats for use with search and rescue units. Yukons are the aircraft being used on Canada's direct logistic support flights to Europe that bypass the Canadian Air Material Base at Langar, England, and will result in its eventual phaseout.
- **Phaseout** of the eight CF-86 Sabre and four CF-100 all-weather fighter squadrons in Europe in preparation for

CL-41R ADVANCED SYSTEMS TRAINER version of Canadair's CL-41A trainer has an F-104G nose section and carries the F-104G electronics packages in aft fuselage "saddlebag" compartments. RCAF has ordered 190 trainers, designating them CT-114 Tutors.

After Voting

CANADIAN BOMARC B anti-aircraft missile is shown on its launching rack. Missiles are in place at North Bay, Ont., and La Macaza, Que., but cannot become operational until they are armed with nuclear warheads.

HERCULES C-130 HEAVY TRANSPORTS are now being flown by Canadian Air Force's Air Transport Command on regular supply flights to Canadian outposts in the Arctic. Aircraft also is being used to airlift partially dismantled CF-104Gs to Europe

their replacement by the eight CF-104C squadrons, which will be completed in 1963. Air base modernization programs also are under way to expand present European facilities to accommodate the new CF-104s.

• **Modernization** of the Maritime Air Command's fleet of Canadair CP-107 Argus anti-submarine aircraft with improved detection equipment. Three Argus squadrons operate on the East Coast and one squadron, equipped with Lockheed P2V-7s, operates on the West Coast.

• **Final preparations** for a switch to all jet pilot training, which is scheduled to begin late this year with the first deliveries of the Canadair CT-114 (CL-41A) basic jet trainer. Royal Canadian Air Force has ordered 190 of the two-place jets, some of which will be equipped with F-104C nose sections and electronics systems for use as advanced F-104G systems trainers.

• **Purchase** of six Boeing Vertol CH-113 helicopters, the Canadian military version of the Vertol 107, for use in search and rescue work. First helicopter was delivered late last year. Remaining five are scheduled for delivery by the end of 1963.

Naval aviation and missile programs suffered cutbacks during 1962. The Navy lost its fighter capability when its Banshee jet squadron, VF 870, was decommissioned. No replacement is programmed because of the limited capability of the Navy's sole aircraft carrier, the Bonaventure, to handle high-performance aircraft. Since re-equipment with a new fighter would require a new carrier, Navy officials see little hope of regaining the capability. Future of the Bonaventure, now an ASW helicopter carrier, is in doubt.

Navy's program for a surface-to-air missile fared little better, for its development was ruled out because of the austerity cut. A $22 million program to fit platforms on destroyers for Sikorsky HSS-2 anti-submarine helicopters (AW Aug. 30, p. 31) is progressing on schedule, however. Sea trials begin this fall.

Canadian Army's campaign for more aircraft in the heavy helicopter and utility transport categories met with partial success when the Canadian government ordered 12 Vertol 107s, designated CH-113A by the Army, for use as troop and equipment transports.

Army presently has a fleet of Cessna L-19 observation-liaison aircraft and Hiller CH-112 light reconnaissance helicopters. Army officials want to build a transport fleet of de Havilland STOL Caribous to increase mobility and a heavy helicopter fleet for use in vertical envelopment attacks. A situation resembling that existing in the U. S. military structure exists in Canada, with the Air Force insisting it should maintain control of the airlift capability.

Canadian purchase of CH-113As may be the first step in giving the Army a troop and light cargo airlift capability. At one time during the nuclear dispute, the Canadian government proposed to shift Canada's military commitments to a highly mobile conventional force. Future of this concept will remain uncertain until Canada's nuclear policy is resolved.

Canada moved into the space age during 1962 with the successful launching of the Canadian Alouette research satellite (AW Oct. 8, p. 34). The Alouette was developed by the Canadian Defense Research Board and built by de Havilland of Canada, Ltd., Toronto. RCA and Sinclair Radio Laboratory of Toronto produced the electronic and telemetry systems. The satellite was placed in orbit from Vandenberg AFB, Calif., by a Thor-Agena rocket provided by the U. S. National Aeronautics and Space Administration.

Four more Alouettes are scheduled for orbit in the next five years under a $60 million program, to which the U. S. is contributing $35 million. Three new satellites and the back-up vehicle for last year's orbital shot will be used.

Canada's aviation industry maintained an uncertain existence during 1962, with industry leaders looking for a definite defense policy on which to base future plans.

De Havilland continued a monthly production rate of four Caribou 1 utility transports against total orders of 180 from the U. S. Army, the Republic of China, Ghana, Sweden, India and the Canadian Air Force. Production is expected to reach six a month by mid-year.

Future programs at de Havilland include development of the larger turboprop Caribou 2 for the U. S. Army (AW July 23, p. 26) and the STOL Otter research program which is aimed at developing a reverse thrust package to improve Caribou STOL performance (AW Feb. 18, p. 67).

Canadair has a variety of programs under way, but had to reduce its work force to compensate for a slowing down of CL-44 and CF-104G production.

The Canadian Air Force CF-104G order also is nearing completion and production of the 120 additional CF-104s funded by the U. S. for the NATO Military Assistance Program is not scheduled to begin until mid-year. Monthly production has been gradually reduced from 12 to 4 aircraft in an effort to keep the production line open.

Canadair's CL-41A jet trainer is on schedule, with the first production aircraft due off the line in October. A 10-station overhead monorail production line is being used on the CL-41 program to speed assembly of the main fuselage section.

Canadair also is seeking development of future aircraft with a conversion package program for the CL-41 basic airframe and its proposed CL-84 V/STOL liaison-reconnaissance aircraft (AW Feb. 18, p. 43).

Orenda Engines, Ltd., in Toronto, depended primarily on the J79 engine production in support of the CF-104 program during 1962. Orenda reached a peak production of 15 engines a month last year, but has since reduced this rate to 9.

NORD AVIATION'S C-160 TRANSALL cargo prototype made its first flight recently. Aircraft is being built jointly for the French and German air forces (AW Mar. 4, p. 32). Transport is powered by two Rolls-Royce Tyne turboprop engines.

West Germans Seek Industry Unification

West German Defense Ministry is actively pushing its demand for a major reorganization designed to weld the nation's aerospace industrial complex into a single entity responsible for most research, development and production.

Impetus behind the move is a growing need to obtain the best possible return from an overstrained industry where experienced technicians are at a premium by holding duplication to a minimum and by providing the government with a single communications channel through which it can coordinate and monitor future programs.

Ways, means and an acceptable timetable for final integration have been under discussion by industry and government officials for the past three months but consolidation is complex, since large shares of the various companies affected are in private hands.

The industry was resurrected from its postwar impotence largely by government aid and subsidy, and it is dependent upon defense contracts for its livelihood. Thus, the Defense Ministry has a sizable voice in its day-by-day operation as well as in its over-all operational and organizational structure.

A number of industry officials agree with the aims of the project, although there is concern as to how ownership of the integrated parcel is to be apportioned between the government and private shareholders.

The new organization would go far beyond the present, largely informal structuring of the industry into North and South Groups. As originally conceived, the South Group of Messerschmitt, Heinkel, Dornier and Bolkow was to to become the manufacturing arm of the licensed production program for the Lockheed F-104G interceptor. The North Group was to concentrate primarily upon development and production of transport aircraft.

As the German portion of the multination F-104 program expanded, it quickly outstripped the industrial capacity of the South Group. Members of the North Group as well as Dutch and Belgian firms were called in on the project.

Since then, the two groups largely have lost their identity and meaning. Members of the South Group have worked with their opposite numbers in the North Group on several projects. Dornier, in the fighter-oriented South Group, won the government contract for a V/STOL transport, while Focke-Wulf in the transport-oriented North won a competition for a V/STOL strike fighter design.

Integrating the industry would simplify not only channeling and division of work on future multination production projects but also the Defense Ministry's coordination of these programs internally as well as externally. Although Germany is still anxious to build its own industry as an instrument of prestige, employment and technological development, its participation in multination projects may grow under the evolving philosophy of its present military leaders.

Gen. Werner Panitzki, new West German air force chief, believes as a military man he must reject any purely national aircraft production program where vulnerable German facilities would represent the only source of supply. For most major programs, he would prefer a link with the U.S., where he believes production facilities would stand a greater chance of survival than in Europe, even in the event of a nuclear exchange with Russia.

Aside from tactical missiles, where Germany's procurement program is becoming increasingly obscured by an ambivalent U.S. policy regarding their availability, the nation's major military aerospace goal centers around acquisition of a family of V/STOL aircraft. These would lessen dependence upon conventional airfields where activity can be continuously monitored on the radar scopes of Eastern Europe.

Germany would like to cooperate with the U.S. in this area to gain some assurance that a back-up logistics source might be available after any initial Soviet thrust toward the West. Such a move, however, will depend upon a final U.S. Defense Dept. clarification as to what it wants—and when—in the V/STOL field. West German Defense Ministry planners feel that combat V/STOL aircraft must become operational within the German air force during the early 1970s.

Of Germany's own projects in this field, the Focke-Wulf 1262 close support fighter and the Dornier Do-31 medium range transport appear to have the best chance of production.

The 1262, developed under government contract, has been designed to use the Bristol Siddeley BS.94 vectored thrust turbojet for its main propulsion unit and two Rolls-Royce RB.162 lift engines housed in the wings. No development funds are

available for the BS.94, however, and Focke-Wulf is considering an alternate design incorporating two deflected thrust versions of the Rolls-Royce Spey.

Germany appears to be willing to integrate the 1262 design with projects and requirements of other nations to gain a multi-lateral production base for a V/STOL close-support aircraft to replace German Fiat G.91 strike fighters.

Relying primarily upon ground-to-air missiles for air defense, German air force planners foresee only a limited requirement for high-performance V/STOL aircraft to replace the F-104 in the early 1970s. Under present planning, these would be used primarily for long-range reconnaissance and strikes against moving targets.

An aircraft to fit this role, the VJ-101D, has been under development with government support by an industry team from Messerschmitt, Heinkel, Dornier and Siebel. A testbed version has been flying since last fall. Future of the project is in doubt, however, partly because of the limited requirement foreseen for the aircraft and partly because of Germany's desire to procure equipment that also will be in service with and manufactured by other members of the Western alliance.

In its present design configuration, the VJ-101D would be powered by two Rolls-Royce RB.153 powerplants adapted for deflected thrust and housed in the fuselage and a bank of RB.162s for use in the vertical flight regime.

In Gen. Panitzki's philosophy, manned interceptors have little value to West Germany whose proximity to Communist Eastern Europe means that practically no advanced warning of an incoming attack would be available. Consequently, he would like to see a shift in roles and missions within the North Atlantic Treaty Organization that would free the German air force of its present commitment to assign two F-104G wings to the NATO interceptor force.

Instead, Gen. Panitzki would prefer to rely on quick response ground-to-air missiles for an active on-site air defense, using his full force of approximately 700 F-104s when they become available for strike and reconnaissance missions under an offensive air defense concept. Germany, in essence, would assume a greater strike and reconnaissance role within NATO, and other European nations that could expect more adequate warning would take over a larger share of the manned interceptor mission.

One problem is use of an aircraft that was designed first as an interceptor and then adapted to a strike role with nuclear weapons in the role of a tactical fighter carrying only conventional weapons. Earlier plans for utilization of the aircraft have been shelved, and the West German F-104 strike fighter wings are currently scheduled to be used as part of NATO's conventional warfare arm now being strengthened under White House prodding.

Germany—despite its collaboration agreement with France, which has ignored President Kennedy's conventional warfare requests—has agreed to accept the conventional force philosophy as long as it is backed by a strong tactical and strategic nuclear arm. Furthermore, Germany intends to continue to cooperate with the U.S. government and U.S. industry in the development and production of new weapon systems, unlike France which now appears willing to buy American only when there is no other recourse.

The Franco-German agreement could foster joint development of a high-performance V/STOL interceptor and reconnaissance aircraft built around the designs of the VJ-101D and France's Mirage IV. It also could mean an end to efforts within the German air force, army and navy to persuade the country's political leaders to abandon plans for licensed production of France's SA 3210 Super Frelon heavy helicopter and to adopt the Sikorsky S-61 instead.

The agreement covers large areas of defense, including coordination of some research and development projects as well as production efforts. Each country's defense ministry will draft a list of proposals for cross submission and afterward an agreement will be made on specific joint projects to be undertaken by the respective industry and research teams.

Also included are provision for bilateral strategic and tactical studies and deployment and acceleration of joint maneuvers and training exercises.

Any permanent stationing of German air force combat units in France, a possibility for its interceptor wings if Gen. Panitzki's plan continues to meet resistance, probably would have to be approved by NATO. Joint maneuvers and training exercises can be arranged largely on a bilateral basis, however. German air force units, as an example, have been flying to the French-owned, NATO-built gunnery and bombing range on Corsica for training missions for two years.

In the transport field, Dornier seems assured of a sizable air force order for the Do.31 V/STOL medium-range military transport. The aircraft is now scheduled to be powered by two Bristol Siddeley BS.53 type vectored thrust engines, one podded beneath each wing.

Focke-Wulf has a V/STOL transport design that is somewhat larger than the Do.31, but it has no government development support. Designated the FW.260, the 85-passenger aircraft would have a Mach 0.85 cruise speed over stage lengths of 300-1,200 mi. Vertical lift would be obtained from two wing pods, each housing six pure lift engines—either the Bristol Siddeley BS.59 or the Rolls-Royce RB.162.

Germany is pressed for funds to meet other requirements, and its former encouragement to industry to design and produce commercial transport aircraft has been lacking recently.

A second commercial transport design, the Heinkel 211 series, will remain on paper until—and if—the government provides $9 million to carry the project through development.

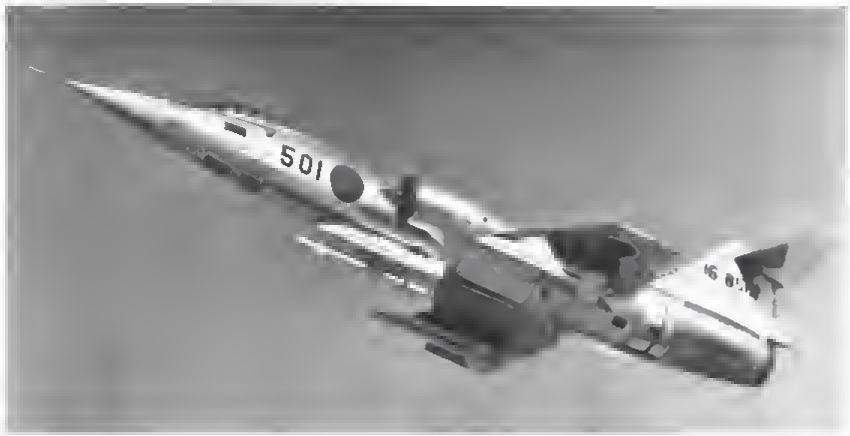
Heinkel, to generate interest in the aircraft as well as assure a future domestic market, has been negotiating with Deutsche Lufthansa West German Airlines for a possible order for the turbojet HE 211B-1 version of the short-to-medium-range transport, but no firm decision has been reached.

Present plans call for the 211B-1 to be powered by two General Electric CF700-2B fan engines of 4,200 lb. thrust each. An alternate installation is three 2,850-lb. thrust General Electric CF 610 turbojets, also mounted in the aircraft's tail section. The 24-passenger turbojet is designed primarily as a DC-3 replacement to operate economically over stage lengths of approximately 700 mi. Cruise speed is 542 mph.

A turboprop version, the HE211A-1, also has been proposed using two Lycoming T55 engines of 2,200 shp. each. The low-wing design would carry 23-25 passengers over a maximum range of 444 mi. at a cruise speed of 380 mph.

In the helicopter field, Bolkow has obtained government funding for construction of three Bo 49 two-man test vehicles to evaluate its high-speed lead-lag rotor system, designed to reach 200 kt. Production dates have slipped slightly, but first of the three is now scheduled to roll out by late spring or early summer, and hover tests should be under way by early fall.

West Germany this year also plans to accelerate its move into space. Last year, approximately $2.5 million was available for civil space projects. This year, as German commitments to the European Launch Development Organization and the European Space Research Organization begin to be felt, funding may increase to $25 million, and the total is expected to grow proportionately during succeeding years.



LOCKHEED/MITSUBISHI F-104J armed with four Sidewinder air-to-air infrared missiles

Japan Embarks on Defense Modernization

Tokyo—Japan's aerospace technical spectrum is gradually broadening, stimulated partly by requirements of a 5-year defense buildup and modernization program begun last year and partly by a search for longer range projects to fill the void that will be left when the program phases out in 1966.

Because of the program, initiated in 1961 by the Japanese National Defense Council and by the Cabinet, Japan's aviation industry has an order backlog that promises a respectable volume through 1965—largely manufacturing U. S. designed aircraft.

Concerned at the post-1965 prospects, however, Japanese industry is beginning to emphasize its own design capability.

In common with international trends, Japan's aviation industry is moving to lower volume, higher unit cost production. Last year, unit production totalling 105 aircraft was well below the 1957 peak of 227 aircraft. But value of last year's total, including engines and accessories, reached a postwar record of $55.5 million. The 227 aircraft in 1957 represented only $20 million worth of business.

Budget for the Japanese Air Self Defense Force trails the ground forces in size, but has been rising at a faster rate since 1960 than either the Ground or the Maritime Self Defense Force. For the 1962 fiscal year, ending Mar. 31, 1963, the air force total reached approximately $165 million.

Under the 5-year defense program, the air force will remain at about its present strength of 1,100 aircraft. Two thirds of this currently consists of jet fighters and trainers—F-86Ds, F-86Fs, T-33s and Japanese-designed Fuji T-1As. It also operates 30 helicopters. In addition, the navy has about 190 fixed wing aircraft—P2V-7s and S2Fs—and 30 helicopters, the army about 70 helicopters and 190 fixed wing aircraft.

Like Germany, Japan is buying a technological leap forward with manufacture or assembly of 200 Mach 2 Lockheed F-104s, which the Japanese will phase into the Air Self Defense Force by 1965.

Twenty F-104J interceptors and 20 F-104DJ trainers were manufactured in the U. S. and knocked down for shipping and reassembly in Japan. First of these aircraft was flown last April and delivered to the air force.

The remaining 160 aircraft, all interceptor versions, will be almost entirely manufactured in Japan, and delivery of the first all-Japanese aircraft is scheduled for this month. Mitsubishi Heavy Industries, Reorganized, Ltd., is prime contractor, with Kawasaki Aircraft Co. as subcontractor.

Japan has not had the management problems of the European program but there have been technical obstacles. The Japanese did not allow for the same range of tolerances in the airframe as American practices require, and the result was extra effort to cut and fit sections by hand.

First Japanese manufactured J79-11 turbojet engine for the F-104 has completed two 150 hr. flight rating tests. Engine production by Ishikawajima Harima Heavy Industries will not use the same degree of Japanese made components as the airframe—probably reaching only approximately 50-60% of the total.

Even though delivery of the F-104J is at hand, the Japanese are still debating award of a contract for a modernized command and control system to integrate the F-104 and new anti-aircraft missiles into Japanese air defense.

Debate over choice of a system, centering over cost, system evaluation and Japanese domestic political and economic factors, has been under way for 18 months. One Japanese team evaluated competing systems in the U. S. last fall using high performance U. S. interceptors, but another evaluation may be made before a decision is reached on the system.

Competing for the system, roughly a Japanese version of the U. S. SAGE, are:

- **General Electric's** recently formed Japanese joint venture with Toshiba (Tokyo Shibaura Electric Mfg. Co.), proposing basically the GPA/73. This is part of the U. S. 412L Air Weapons Control System and nine copies of it are deployed in Germany. Initial cost is estimated at $83 million, but may go higher.
- **Litton Industries** teamed with Mitsubishi Electric and Fuji Communications Apparatus Mfg. Co., offering Litton's Marine Tactical Data System (MTDS) now in service with the U. S. Marine Corps. Initial cost of this system, also known as Modicon (Modular Control), is $52 million.
- **Hughes Aircraft Corp.** teamed with Nippon Electric and offering the Hughes Tactical Air Weapons Control System (TAWCS) elements of which have been used by all three U. S. services. Its initial cost is estimated at $40 million.

U. S. funding is involved, and thus the U. S. urging to the Japanese to make a decision in time for handling in the Fiscal 1964 budget processing. Further, U. S. services have interest in the purchase of systems which they have supported.

Japan's own aircraft design and engineering capability—confined since World War 2 to the Fuji T-1A jet trainer, except for lightplanes—is broadening into several programs with possible future potential.

- **Nihon YS-11** 52-60 seat short-haul transport powered by two Rolls Royce Dart 10/1 Mk. 542 turboprop engines. Two prototypes flew for the first time last year. Certification by the Japanese Civil Aviation Bureau is scheduled in October and first delivery is programmed for 1964. All Nippon Airways has ordered 20, the Japanese Self Defense Agency two for VIP transport, and the Civil Aviation Bureau one for test and utility transport use. No military order has been mentioned, but the Japanese Air Self Defense Force, using Curtiss C-46 piston engine aircraft for transport, is a potential customer. First delivery of the YS-11 transport will be to the Civil Aviation Bureau for certification.
- **Four-engine modification** of the Grumman UF-1 Albatross, under test by the Maritime Self Defense Force as an anti-submarine aircraft. Test flying began early this year, and Shin Meiwa Industry Co., which carried out the modification, is hoping for further development and manufacture. Shin Meiwa, with Kawasaki as subcontractor, was in process of delivering the last of 42 Lockheed P2V-7 ASW patrol aircraft to the Japanese navy early this year.
- **Light-twin turboprop** utility transport or reconnaissance aircraft under development by Mitsubishi. Designated the MU-2, the 6-place aircraft will be equipped with two 500 shp. engines and cruise at 300 mph. A prototype will be completed this year.
- **Light-twin development** of the Beech T-34 Mentor trainer at Fuji. A modification of the T-34 is now being produced by Fuji under the designation KM-2, and 25 of an order of 30-40 will be delivered this year.

Japan is relying to a greater extent on its own design in the area of battlefield and anti-aircraft missiles. Kawasaki has completed testing of its wire-

FIRST PROTOTYPE Nihon YS-11. Two prototypes were completed and flown last year

KAWASAKI/VERTOL KV-107 twin turbine helicopter (above) was built in U. S. and assembled by Japanese. Increasing share of future manufacture will be by Kawasaki

SIKORSKY/MITSUBISHI S-61 for Nitto Airways (below) also manufactured in the U. S.

FUJI T1-B trainer is powered by 2,600 lb. thrust J3 IHI-3 turbojet developed by Japan's Nippon Jet Engine Co. and manufactured by Ishikawajima Harima Heavy Industries. Fuji T1-A is powered by a British Bristol Orpheus Mk 1 turbojet engine.

PROTOTYPE SHIN MEIWA UF-XS, a modification of the Grumman HU-16E Albatross, is a testbed for a Japanese ASW and rescue flying boat that will be designated the PX. Japanese specifications indicate two Pratt & Whitney R1340 piston engines have been added outboard of the two Wright R1820 engines normally equipping the HU-16F, and that two General Electric T58 engines are carried, possibly for boundary layer control.

guided AAM anti-tank missile and production is expected to begin this year.

Development is still continuing of other Japanese missiles in these classes, including the AAM-2 air-to-air weapon and the TMB-0, TSAM-1 and TLRM-2 surface-to-air missiles. All are Mitsubishi projects.

Defense Buildup

In the meantime, Japan is buying Nike-Ajax anti-aircraft missiles and Hawk low-altitude anti-aircraft missiles from the U. S. as part of the defense buildup. Two battalions of each are planned, and equipment for the first Nike-Ajax battalion is due for delivery in April. Purchase of the air-breathing Boeing Bomarc for Japan's air defense also was under discussion.

Development of VTOL aircraft is attracting increasing interest in Japan for long range application and greater support to industry in this field is expected from the Industrial Science and Technics Agency of the International Trade and Industry Ministry. Projects include:

- **VTOL transport** in the 250-300 kt speed and 300 mi. range class, and designed to carry 50 passengers. The project is under study by the VTOL department of the Aircraft Industry Council, which is part of the International Trade and Industry Ministry.
- **VTOL testbed** under design by the Aeronautic Institute of Tokyo. This project, financed by a $400,000 Education Ministry subsidy, will probably utilize a lift engine.
- **Tilt-wing aircraft** under development by Mitsubishi.
- **Turbojet lift engine** under development by a Jet Engine Study committee, which is part of the National Aeronautical Laboratory of the Science and Technics Agency. Under study is a 135 lb. engine developing about 2,500 lb. thrust, or almost a 20:1 thrust-to-weight ratio and designated XJ-11. Construction of 5-6 test engines over a two-year period is planned.

Currently, Japan's aviation industry is adding to its manufacturing capability in the rotary wing field, aiming not only at commercial markets in Southeast Asia but also at Japanese military orders that are expected as part of the defense modernization program.

Mitsubishi is building both the Sikorsky S-61 twin turbine helicopter and the single turbine engine S-62 under license, at relatively low production rates. Complete components for one flyable S-61 were delivered last year and component kits for two more have been ordered from Sikorsky for delivery early this year. Further parts procurement is expected. Eventually, the Japanese will supply most of the production components, possibly excepting some dynamic components.

Similarly, Kawasaki imported two completed Vertol 107s, but has received eight more in kit form for gradually expanding its manufacturing capabilities for the helicopter. Fuji has imported a single Bell HU-1B which it assembled, and plans to begin manufacturing the helicopter in 1964.

Prospective Japanese military orders are stirring much of the helicopter activity. Side-by-side evaluation of the S-61 and the KV-107 by the ground forces began early this year. Navy is looking at both twin turbine helicopters for anti-submarine use, but has purchased two KV-107s for minesweeping use. Air force is interested in a utility-rescue helicopter of the S-62 class.

The Japanese also have a space program under way and may be able to orbit an 88 lb. satellite by 1967. It's being directed by the Institute of Industrial Science, a government research body, and Tokyo University.

Sounding Rockets

In the past seven years, the group has launched about 90 sounding rockets. About 30 were the so-called Kappa type and a Kappa-L rocket has reached a height of 217 mi., the Japanese peak so far. The Japanese are particularly interested in studying meteorological data—winds, temperatures, density.

Currently, the Japanese are developing a Lambda rocket, a 2-stage solid fuel booster, with which the Japanese hope to reach 400-500 mi. Later, they plan to add another stage and push the rocket to 930 mi.

Japan's 1963 budget for this program is $1.2 million, compared to $800,000 in Fiscal 1962. Included is a new launch site in southern Japan facing onto the Pacific Ocean. Previously the Japanese had been firing into the Japan Sea on the northwest coast. But as their range increased, they shifted the launch site to prevent any rockets from falling into Soviet Russia.

Zuckert Defends F-111 Winner Selection

Senate unit extends investigation, hears conflicting cost data; Rep. Wright denounces investigation.

By George C. Wilson

Washington—Air Force Secretary Eugene M. Zuckert last week released a memorandum explaining his selection of General Dynamics-Grumman for the F-111 (formerly TFX) development contract while the Senate tried to clarify conflicting cost figures for the aircraft and House members charged that the whole investigation was unfair.

Chairman John L. McClellan (D-Ark.) of the Senate investigations subcommittee said the probe will take longer than the five or six days he anticipated. He said he presumed Defense Secretary Robert S. McNamara will testify before the hearings end. They are slated to continue this week.

So far, none of the civilian Defense Dept. officials who reversed unanimous recommendations by joint USAF-Navy source selection boards that Boeing be awarded the F-111 contract have testified. But Defense Dept. on Mar. 3 released most of the memorandum Zuckert wrote on Nov. 21, 1962, explaining why he picked General Dynamics-Grumman rather than Boeing. The Senate committee had released only a portion of Zuckert's statement (AW Mar. 4, p. 22).

Zuckert's Memo

The Zuckert memo said: "It is apparent from the evaluation that the Boeing and General Dynamics proposals although possessing strong dissimilarities, are rated equally. In the raw score comparison, General Dynamics received 175.6 points and Boeing 172.1, a difference of less than 2%." He said the Air Force gives "a significant edge to the operational characteristics of the Boeing aircraft because of its longer ferrying range, greater fire power and the provision of thrust reversers for increased maneuverability.

"The Navy also favors Boeing's operational features," the memo said, "but to a lesser degree, attributable in part to the lower number of Boeing aircraft which could be accommodated aboard a carrier. . . . In the Navy version, the Boeing proposal has a speed restriction which would require additional weight to be added. The General Dynamics aircraft is slightly inferior in weapon selectivity and carrying capability, however, its superior supersonic performance and lack of a speed limitation are considered to be basic advantages which can overcome the deficiencies. Inasmuch as either of the proposed aircraft can perform the mission required by both services, and the evaluation of the proposals provides no overriding margin between the competitors, it is necessary to consider other factors in evaluating these aircraft."

These "other factors," the Zuckert memo said, were the "distinct edge" General Dynamics had in using common equipment and parts on the Air Force and Navy versions of the F-111, possible structural problems from Boeing's intended use of titanium, a fear expressed by the Navy; Boeing's over-optimistic estimates of the cost of engineering tooling and manufacturing; superior experience General Dynamics-Grumman had in building supersonic and Navy aircraft.

"In analyzing the summary of ratings in the evaluation," Zuckert said, "it is pertinent to note that the General Dynamics evaluation exceeds Boeing's in the technical areas of air vehicle, propulsion flight control, secondary power and environmental control, mission and traffic control, aerospace ground equipment, crew provisions and personnel subsystems. These favorable areas, in our opinion, outweigh the deficiencies in offensive systems, reconnaissance and penetration aids."

Just how much less expensively Boeing could produce the 1,700 aircraft than General Dynamics-Grumman became a central question in the subcommittee's inquiry last week. USAF Col. Charles C. Gayle, project director of the F-111, said his evaluation group had erred in its cost estimates during the fourth and final evaluation. The mathematical error increased USAF's figure for Boeing $77.5 million. Col. Gayle said he was not sure Zuckert knew of the error at the time he made the final decision to select General Dynamics.

These were the various estimates of what it would cost to develop and produce the required number of aircraft—contractors' own estimates: General Dynamics-Grumman, $5,455,500,000; Boeing, $5,364,200,000; a difference of $91,300,000. First Air Force adjustment of these figures by adding cost estimates for additional requirements: General Dynamics-Grumman, $7,083,200,000; Boeing, $6,983,000,000; a difference of $100,200,000. Air Force adjusted figures comparing proposals directly rather than including estimates of additional requirements: General Dynamics, $5,803,000,000; Boeing, $5,465,000,000; a difference of $338,000,000. Air Force final estimates after finding mathematical error: General Dynamics, $5,803,000,000; Boeing, $5,387,500,000; a difference of $415,500,000.

Gayle Statement

During the extensive questioning of Col. Gayle, he said: "I believe that I have stated to Boeing on several occasions that they could use more experience in Navy work and fighter experience." Despite such advice, Boeing decided to go it alone rather than join forces with another company with Navy experience.

The dispute over the F-111 contract award spilled over to the House. Rep. James C. Wright, Jr. (D-Tex.) of Ft. Worth, Tex., where General Dynamics would build the F-111, said: "The odd assumption behind the investigation in the other body seems to be that Boeing receives contracts solely on merit, but a competitor could only win by some undisclosed chicanery." Part of the justification for giving the contract to General Dynamics, Rep. Wright said, was that "in the absence of a substantial contract of this type, the General Dynamics team at Ft. Worth was faced with dismemberment."

Syncom Position

Washington—Range and range rate information obtained from the tracking ship Kingsport off the Nigerian coast provided look angle information from which telescopes located the silent Syncom satellite in orbit over the southern tip of India at an altitude of about 22,000 mi. It was the first use of range and range rate data to calculate the position of a satellite.

Syncom was launched Feb. 14, and went silent 5 hr. 7 min. after launch (AW Feb. 25, p. 30). During the time it was on the transfer ellipse from low to synchronous orbit, the Kingsport obtained carrier Doppler and phase shift data during two 15-min. segments. On the basis of the data, Goddard Space Flight Center was able to calculate look angles and make orbital predictions. The information was given to the optical station at Bloemfontein, South Africa, which sighted the satellite Feb. 24, Feb. 25 and Mar. 2. It appears as a star of the 17th magnitude, and drifts 2 deg. eastward each day.

No Major Advance Seen in U.S. Nuclear Test Detection Capability

By Katherine Johnsen

Washington—U S capability to detect and identify underground nuclear detonations—the key to a test ban agreement—has gradually, but not spectacularly, improved over the four year life of the Vela Umform project, Advanced Research Projects Agency reported last week to the Joint Committee on Atomic Energy Dr J P Runa, ARPA director, said

"Important as some of the new results have been and however significant the change in the whole technical picture has been, in no technical sense can any of the individual developments be considered scientific breakthroughs Such breakthroughs are possible but they are entirely unpredictable What is predictable is the kind of gradual improvements which we have achieved "

Approximately $100 million has been invested in Vela Umform by Defense Dept , of which ARPA is a part, with another $20 million programed for Fiscal 1964

Dr Runa said the results of intelligence activities and political factors, as well as technical factors, determine the advisability of a test ban

In the area of detection, the U S is now proposing to rely primarily on a capability located outside the territory of the USSR Dr Carl F Romney, assistant technical director of Air Force Technical Applications Center, estimated that this would require 15 stations costing about $1 million each The annual operation would cost about $10 million, he said

Without further research, the system would detect

• **Detonations in granite** of 1 kiloton or more One kiloton would be considered the "detection threshold" for granite

• **Detonations in tuff**—a volcanic matter found in Nevada—of six kilotons or more, and probably all detonations over two kilotons

• **Detonations in alluvium**—a sandy matter—of 20 kilotons or more, and probably all detonations over 10 kilotons Sen John O Pastore (D-R I), chairman of the committee, raised the possibility that a nuclear detonation of just under 20 kilotons, comparable to the Hiroshima explosion, could go undetected

Dr Runa noted that dry alluvium, the material in which a nuclear detonation is the hardest to detect, "does not occur to depths sufficiently great to assure non venting of fission products except in a relatively few desert areas of the world " Fission deposits in the atmosphere are readily detectable

Nuclear detonations, detected at the detection thresholds for granite, tuff, or alluvium, would have to be singled out from about 170 earthquakes annually in the USSR Romney said

U S is now negotiating for seven on site inspections in the USSR to identify possible violations of a test ban

Of the 170 earthquakes Dr Romney said, about 20 could be identified with certainty, without on site investigation, and an additional number of about 75 could be identified with a high degree of positiveness This would leave about 75 earthquakes that could be confused as possible nuclear explosions, with identification possible only by on site inspection

NASA Briefs Firms On Voyager Studies

Washington—Bidders' briefing is to be held at National Aeronautics and Space Administration headquarters here Mar 11 on six-month conceptual studies of Voyager planetary orbiter and lander spacecraft

Invitations were sent to 21 companies on Mar 5 Bids will be due Mar 25

The space agency will award two contracts for the studies

Work statement calls for engineering studies of three payload configurations which would be launched by Saturn 1, 1B and 5 vehicles Emphasis will be placed on a 6,000 to 7 000-lb spacecraft with a 150-in maximum dimension

This payload would be launched by a Saturn 1B with a new S-6 third stage Stage would be a cluster of RL10 engines with larger fuel tanks

Smaller payload, weighing 4 000 lb with a 60 in maximum dimension, would be launched by Saturn 1 which also would require a new third stage Work statement also calls for a brief analysis of a 60,000 lb payload with a 260-in maximum dimension which would be launched by a Saturn 5

Payloads would be programed for launch in the 1967 1975 period

Companies invited to bid are Aerojet, Avco Bell Aerosystems Bendix Boeing, Douglas Ford, General Dynamics General Electric, Hughes, Lockheed Martin, McDonnell, Motorola North American, Northrop Philco Radio Corp of America, Raytheon Space Technology Laboratories and Sperry Rand

Re-entry Vehicle

First experimental re-entry vehicle in Air Force's Advanced Ballistic Re-entry Systems Program (ABRES) (AW Dec 10, p 27) was flown about 4,400 naut mi recently down the Atlantic Missile Range Chrysler Corp nose cone, 9 ft long and 3 ft in dia at its base was made of ablative glass-fiber materials and was launched by an Atlas

Bonanza Ban Viewed As Blow to BAC 111

Washington—Civil Aeronautics Board's 3 2 decision to deny Bonanza Air Lines authority to purchase three BAC 111 jet transports (AW Mar 4, p 33) is being viewed here as a severe setback to British Aircraft Corp 's drive to sell the medium-haul transport in U S markets

Although CAB spokesmen have emphasized that the Bonanza decision should not be interpreted as precedent-setting, feeling here is that if Bonanza cannot get the authority, few local service carriers can Bonanza routes appear to be logically suited to the BAC 111, and its traffic growth—a 24% average rate of increase during the past 10 years—has given the carrier one of the highest load factors throughout the industry

CAB officials stress that the decision was based purely on operational economics and was influenced by President Kennedy's mandate that subsidies be eliminated as soon as possible Observers here, however, point out that under the class mail rate subsidy formula, larger aircraft draw less subsidy than smaller aircraft, according to a graduated scale

Meanwhile, BAC's sales program was again bolstered last week when Bramff Airways announced it will take up its option for six additional BAC 111s to bring its order to 12 aircraft and the total of firm orders for the jet transports to 39

British Select AW-681 STOL for RAF

By Herbert J. Coleman

London — British government last week made the first moves toward streamlining its defense establishment along Pentagon lines and gave Gloster Whitworth approval to build the AW-681 short takeoff and landing transport as a replacement for the Royal Air Force's Beverley and Hastings fleet

After a delay of more than a year, the controversy over fulfillment of OR-351 was resolved but not until after Minister of Aviation Julian Amery admitted that the government considered buying a foreign design (the Lockheed BLC 130) to save development costs

Contract went to Gloster Whitworth instead of Short Brothers & Harland, which had proposed a version of the Belfast turboprop transport, because the RAF prefened pure jet power Airplane will be powered by four Bristol Siddeley Pegasus vectored thrust engines with a follow-on VTOL design calling for podded Rolls-Royce RB 162 pure lift engines

Design was frozen on the basis of the Bristol Siddeley powerplants, but Rolls is expected to propose its vectored-thrust version of the Spey engine for the project

In explaining why Short Brothers did not get the contract, Amery said the Belfast STOL would have been about 100 kt slower than the AW-681 and considerably more bulky However, Short Brothers will be allotted a share of the production work, with a number of airframe components farmed out to the Northern Ireland plant

Amery did not disclose costs but the plan probably will involve at least 50 aircraft, and probably more The contract will be worth about $300 million In any event the new V/STOL contract will have no effect on the planned layoff of 3,000 Gloster Whitworth workers in July, but it guarantees that the design team will remain intact

The minister said he realized the decision in favor of the Hawker Siddeley aviation subsidiary is a serious blow to Short Brothers' design staff—now totaling about 700 persons Short Brothers workload, when the 10 Belfast freighters for RAF are finished, includes subcontract work on the Vickers VC 10 four-jet transports, continued development of the Short Skyvan light transport, and production of the Short Seacat missile Future production of the Skyvan will depend on current flight trials according to C W Wrangham, Short Brothers chairman

Following British practice, first move toward construction of the AW-681 is confined to a project study award to Gloster Whitworth Amery said, in reference to Britain's other important VTOL project, the supersonic Hawker P 1154 for RAF and Royal Navy, that he expected the project study to be completed this month

In other projects, Amery said the Ministry of Aviation was backing research into

• **Problems of suborbital** manned flight at speeds up to Mach 14 New chemistry, physics and metallurgical department is being set up at the Royal Aircraft Establishment at Farnborough along with a new materials group at the explosives research and development establishment

• **Royal Radar Establishment** is investigating behavior of pure materials at very low temperatures and Amery predicted a breakthrough in the field as dramatic as that of the transistor

Amery also said a new generation of guided missiles was coming but he declined to discuss any details of the new nuclear weapon for the TSR 2 strike reconnaissance fighter, other than to say it would result in more industry work and greater air force power

Under the defense reorganization plan, as revealed by Minister of Defense Peter Thorneycroft the admiralty, war office and air ministry will be subordinate departments under a new ministry of defense structure (AW Jan 21, p 38) The three services will retain their identities but the service ministers will be directly responsible to the minister of defense

Under the plan, the ministry of defense will be housed in a single building and the chiefs of staff will report to the minister Future of the ministry of aviation, which devotes 80% of its efforts toward military research is still not determined, but it probably will take a new shape as the ministry's research and development establishment and chief liaison branch with the British aviation and defense industry

Revamping the defense establishment is the latest move toward closer integration of the three services, as proposed in the defense White Paper of 1962 (AW Feb 26 1962 p 36) Thorneycroft hopes the reorganization will be well under way by 1964

The defense minister also emphasized that the British defense policy was firmly based on continuation of the nuclear deterrent—the V-bomber force followed by TSR 2 and the Polaris submarine fleet, balanced with conventional forces in Europe and a close working relationship with NATO Motion in Parliament to approve the defense plan was approved by a vote of 323 for and 237 against

Management Termed Apollo Key

Washington — Only major breakthroughs required in the Apollo manned lunar landing program are in the areas of management, and the U S still "has a way to go" in coordinating the work of the several hundred thousand people involved in the program, Brainerd Holmes manned space flight director for the National Aeronautics and Space Administration, told Congress last week

Both Holmes and James E Webb, NASA administrator emphasized in separate House hearings that the agency's $5 7-billion budget request is the minimum funding required to meet the manned lunar landing target date, believed to be February 1968

Holmes said that although management is a problem, Apollo is under control He said NASA has established four "accountable levels of management," each having quickly recognizable scheduling targets These are subsystems major systems, programs such as spacecraft, and launching

Holmes also told the House space committee's manned flight subcommittee that the objectives of Apollo are "to develop the ability to explore the moon before the end of this decade." This is a subtle change from the objective announced earlier—to land man on the moon and return him to earth

Holmes said another group of pilots will be selected as development of the Apollo spacecraft is ended and the new pool may include a scientist First flight will be made by non-scientists because there will be time for only six hours of experimentation, "and an astronaut can probably do as much as a scientist in this time," he said

Dr Hugh L Dryden deputy NASA administrator told the House space committee last week that NASA will be ready to recommend to Congress next year what the next manned flight program will be

Webb said selection and timing of post-Apollo manned flight programs will determine budget levels in future years and that if ambitious missions are selected, the $5 5 billion to $6 billion plateau he predicted earlier will have to be revised upward

Webb said if there are any indications of Soviet development of rockets in the Saturn 5 class the U S big booster program could be accelerated by putting it on a "crash" basis

United's DC-8Fs

New York—Three Douglas DC-8F turbofan freighters ordered by United Air Lines for delivery in early 1964 will be devoted exclusively to cargo use.

Aircraft are, in this respect, like the four Boeing 707-320Cs ordered by American Airlines (AW Oct. 29, p. 43). Neither American nor United's jet freighters will have passenger windows.

United's order involves $19,800,000 and an option for a fourth DC-8F. Planes will connect San Francisco, Los Angeles, New York and Chicago.

News Digest

Radio Corp. of America last week reported operation of a plastic optical maser emitting pulses of crimson light generated from a rare earth ion in an organic polymer. The device could make feasible a flexible class of optical masers due to possibility of using plastics of varying sizes and shapes.

Civil Aeronautics Board has rejected an application by Hi-Plains Airways for subsidized, third-level airline service between Omaha, Kansas City and Denver. Denial of the request may result in permanent abandonment of the third-level concept.

Selection of an industry contractor to build future Ranger spacecraft was expected to be made late last week by NASA. Nortronics Div. of Northrop Corp. is regarded as a leading contender (AW Feb. 25, p. 39).

United Aircraft Corp. last week reported profits of $18,106,561 or $2.60 a common share on sales of $1,160,458,684 for 1962, compared with $10,020,281 or $1.35 a share on sales of $1,094,756,591 in 1961. Increase in net earnings resulted primarily from lower costs in relation to sales, United said.

Goddard Space Flight Center will hold a three-day conference in Washington beginning Mar. 13 to report on the scientific findings of Alouette, Ariel, OSO-I and Explorers 12, 14 and 15.

Air India has plans to purchase two Boeing 707-320Cs subject to approval of Indian government. Aircraft, which would be delivered in 1964-65, would give Air India eight Boeing jets.

British Aircraft Corp., has formed a wholly owned subsidiary to integrate development and production of guided weapons in its other subsidiaries, English Electric Aviation and Bristol Aircraft, which now will concentrate on airframe production.

NASA-Navy Transit Pact

Washington—Agreement establishing working arrangements between Navy and National Aeronautics and Space Administration for civilian use of the Transit navigational satellite system has been signed by NASA and Defense Dept.

NASA will determine the suitability of Transit equipment for civilian uses and develop any new equipment needed. Navy will continue to develop military equipment and determine its suitability, and will furnish NASA with specifications or information necessary to prepare specifications for the civilian equipment. NASA, in turn, will give Navy its test results and any equipment it develops that might meet Navy's requirements.

NASA has about $600,000 in Fiscal 1963 funds and has requested an equal amount in Fiscal 1964 for research and development on a non-military navigational satellite system. National Academy of Sciences, Maritime Administration, Federal Aviation Agency and the Radio Technical Commission for Aeronautics have recommended development of such a system.

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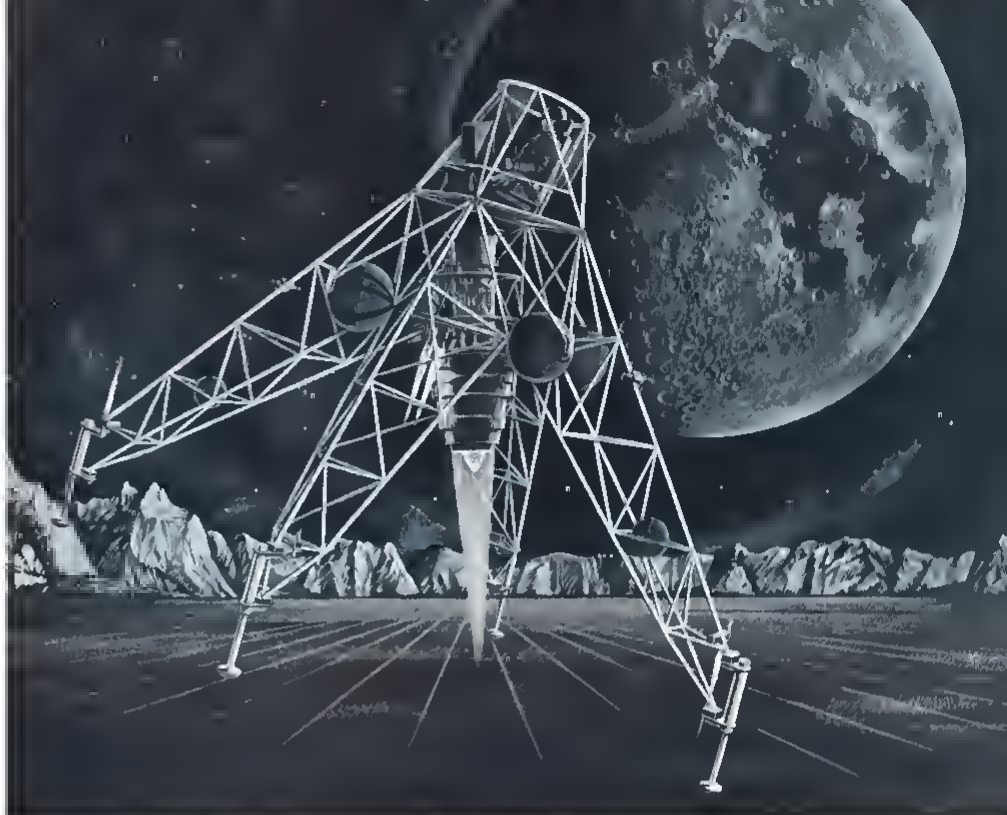

Artist's conception of astronaut training in Bell Lunar Landing Research Vehicle

BELL MAKES MAJOR CONTRIBUTIONS TO NATION'S SPACE PROGRAMS

Lunar Landing Research Vehicles — Moon-bound astronauts will be trained in approach, hover and touchdown procedures for landing on the lunar surface by means of two earth-bound Lunar Landing Research Vehicles being built by Bell for delivery to NASA early in 1964

Velocity Control for Ranger and Mariner—Bell Digital Velocity Meters, with their Bell accelerometers, provide critical inflight velocity data for the Ranger and Mariner probes. Bell has built more than 100 velocity meters for use in important space programs. Over 1,000 Bell accelerometers, the heart of the Bell Digital Velocity Meters, have demonstrated their precision and reliability in service

Reaction Controls for Mercury Astronauts—Bell rocket reaction control systems play a vital part in the success of the manned Mercury and X-15 research airplane programs. Bell is also providing these essential systems for Centaur and Dyna-Soar.

Rocket Power for Gemini Rendezvous — The Bell Agena Rocket Engine, which placed both Ranger and Mariner in parking orbits and then propelled them on their trajectories to the Moon and Venus respectively, will provide main rocket propulsion and the secondary propulsion system for the Agena B rendezvous vehicle in the Gemini program. The 16,000 pound thrust Agena has placed more scientific payload in space than any other engine.

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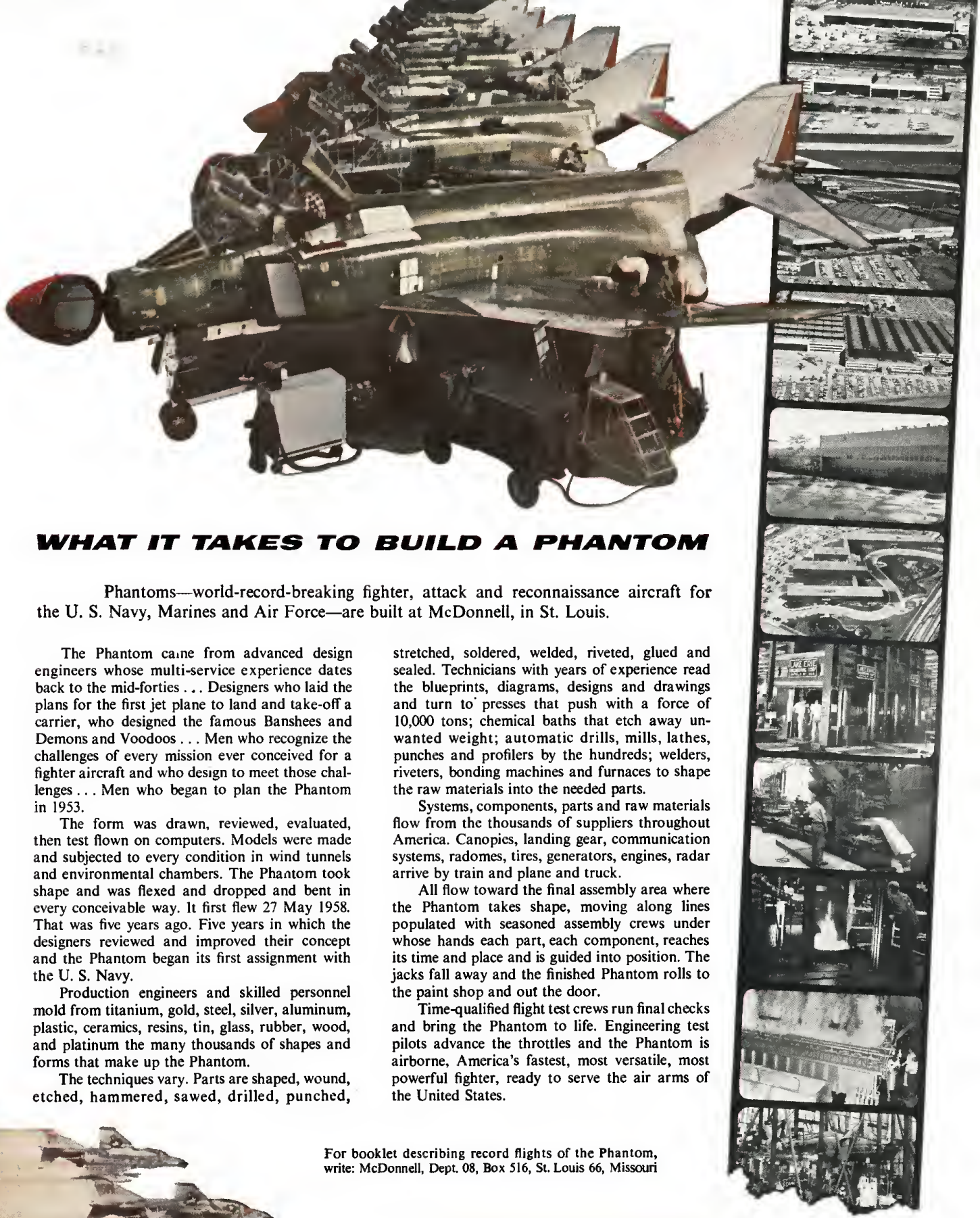

WHAT IT TAKES TO BUILD A PHANTOM

Phantoms—world-record-breaking fighter, attack and reconnaissance aircraft for the U. S. Navy, Marines and Air Force—are built at McDonnell, in St. Louis.

The Phantom came from advanced design engineers whose multi-service experience dates back to the mid-forties . . . Designers who laid the plans for the first jet plane to land and take-off a carrier, who designed the famous Banshees and Demons and Voodoos . . . Men who recognize the challenges of every mission ever conceived for a fighter aircraft and who design to meet those challenges . . . Men who began to plan the Phantom in 1953.

The form was drawn, reviewed, evaluated, then test flown on computers. Models were made and subjected to every condition in wind tunnels and environmental chambers. The Phantom took shape and was flexed and dropped and bent in every conceivable way. It first flew 27 May 1958. That was five years ago. Five years in which the designers reviewed and improved their concept and the Phantom began its first assignment with the U. S. Navy.

Production engineers and skilled personnel mold from titanium, gold, steel, silver, aluminum, plastic, ceramics, resins, tin, glass, rubber, wood, and platinum the many thousands of shapes and forms that make up the Phantom.

The techniques vary. Parts are shaped, wound, etched, hammered, sawed, drilled, punched, stretched, soldered, welded, riveted, glued and sealed. Technicians with years of experience read the blueprints, diagrams, designs and drawings and turn to presses that push with a force of 10,000 tons; chemical baths that etch away unwanted weight; automatic drills, mills, lathes, punches and profilers by the hundreds; welders, riveters, bonding machines and furnaces to shape the raw materials into the needed parts.

Systems, components, parts and raw materials flow from the thousands of suppliers throughout America. Canopies, landing gear, communication systems, radomes, tires, generators, engines, radar arrive by train and plane and truck.

All flow toward the final assembly area where the Phantom takes shape, moving along lines populated with seasoned assembly crews under whose hands each part, each component, reaches its time and place and is guided into position. The jacks fall away and the finished Phantom rolls to the paint shop and out the door.

Time-qualified flight test crews run final checks and bring the Phantom to life. Engineering test pilots advance the throttles and the Phantom is airborne, America's fastest, most versatile, most powerful fighter, ready to serve the air arms of the United States.

For booklet describing record flights of the Phantom, write: McDonnell, Dept. 08, Box 516, St. Louis 66, Missouri

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